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New bargain GPUs reviewed and benchmarked **PG. 74, 80**

CORSAIR ONE i300
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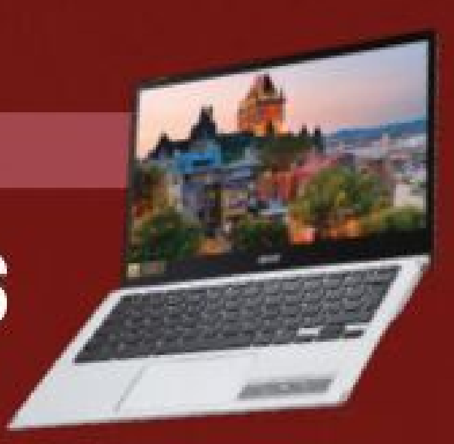

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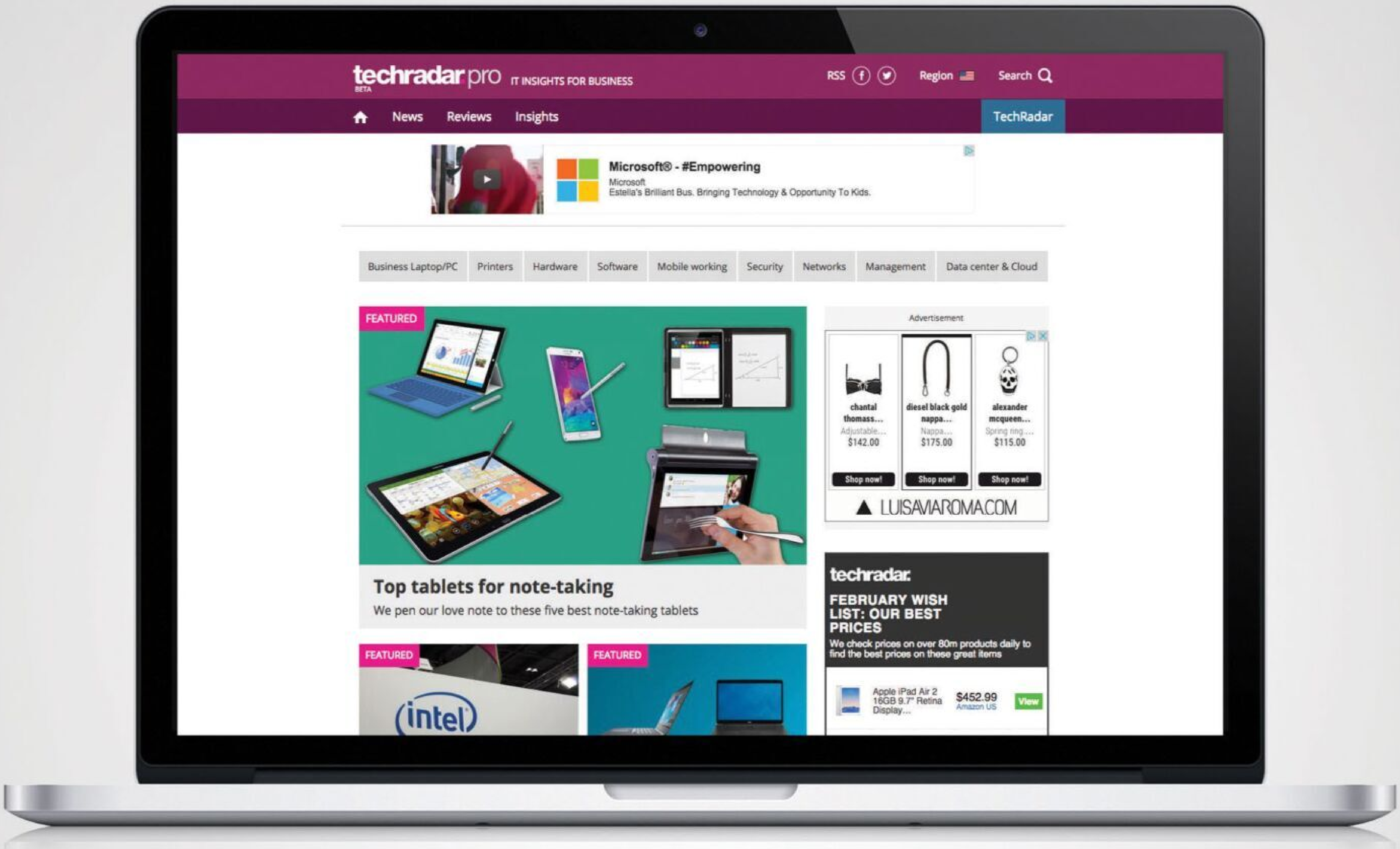
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Guy
Cocker

A TALE OF TWO SYSTEMS

WHEN I JOINED *Maximum PC* last month, my immediate concerns were meeting the team, getting stuck in to our publishing systems, and, of course, getting a magazine out four weeks later (quite important, that last one). By virtue of the fact that my face still appears above, I can confidently say: Mission Accomplished. However, little did I know that I was being eased in gently for a much bigger task this month: tackling the mountain of equipment that had built up at *Maximum PC* towers. No one had warned me that we were on the verge of a PC peripheral-based avalanche so big, it would only be matched by the ensuing mountain of HR paperwork if it ever fell on anyone.

Ever the resourceful editor though, I thought about how I could turn this epic clear out into my first Build It feature. CPUs got re-pasted, RAM modules were re-paired, and AIOs swapped out, and the resulting Frankenstein build was an absolute pleasure. Not just because I got to play with cool stuff, but because it made me feel like I was actually doing something useful, spurring me on to recycle some of the gear I'd gathered at home which was collecting dust in drawers. After finding an MSI B450 motherboard, an AMD 3600 CPU, and some discarded RAM modules, I realized I only needed a case and PSU to make a nice little office PC to give to a friend, relative, or charity. I hope you're similarly inspired!

Our other build this month is rather more up-to-date, with our superstar writer Sam taking on his third cover build in a row. Two months ago, he was let loose on the brand new Intel 12th-gen i9 CPU, building a high-end system around it that cost $3,000. This month, I tasked him to do the same, but at less than half the price, using a frankly ridiculous value 12th-gen i5 CPU and the new RTX 3050. The result is a build that I think embodies the perfect price-to-performance ratio in 2022. Find out how to build it yourself on page 16.

We've also put the traditional Windows PC against two of its biggest competitors in this issue, Chrome OS and Mac OS. Christian ordered in a stack of Chromebooks and Windows laptops to see which deserves a place in students' backpacks this semester. Jeremy, meanwhile, was prepared to don fireproof overalls and stoke perhaps the biggest flame war in tech with his Mac vs. PC feature, where he calls a definitive winner in the age-old battle of the systems.

If there's one disappointment this month, it's the AMD 6500 XT that Jarred reviews on page 80. I'll leave him to explain why, but AMD has basically trimmed so much away on its latest budget GPU that it's seriously hobbled for gaming. It's so basic that cryptocurrency miners will also leave it alone, so you should at least be able to pick one up. Nvidia's 3050 fares better, with its manufacturer including enough RAM to make it worth buying—but still expect to pay over the odds for one.

Before I go, a quick thank you to all the readers who wrote to welcome me to *Maximum PC*, as well as those who took the time to tell me all the things we could improve! From the whole team and I, we hope you enjoy the issue.

Guy Cocker

Guy is Maximum PC's new Editor-in-Chief. He built his first gaming PC in 1997 to play Tomb Raider on 3dfx, and has been obsessed with all things PC ever since.

↘ submit your questions to: editor@maximumpc.com

THE NEWS

Intel's ambitious investment plans

Team Blue is back with a bang

EVERY YEAR, the big-wigs at Intel have a meeting with major investors to keep them up to date. There's often plenty of stuff to interest consumers, but this year's Investor Day proved to be particularly tasty. For starters, Raptor Lake, Intel's 13th generation processor, had its first public demonstration and we also got some solid specs to chew over.

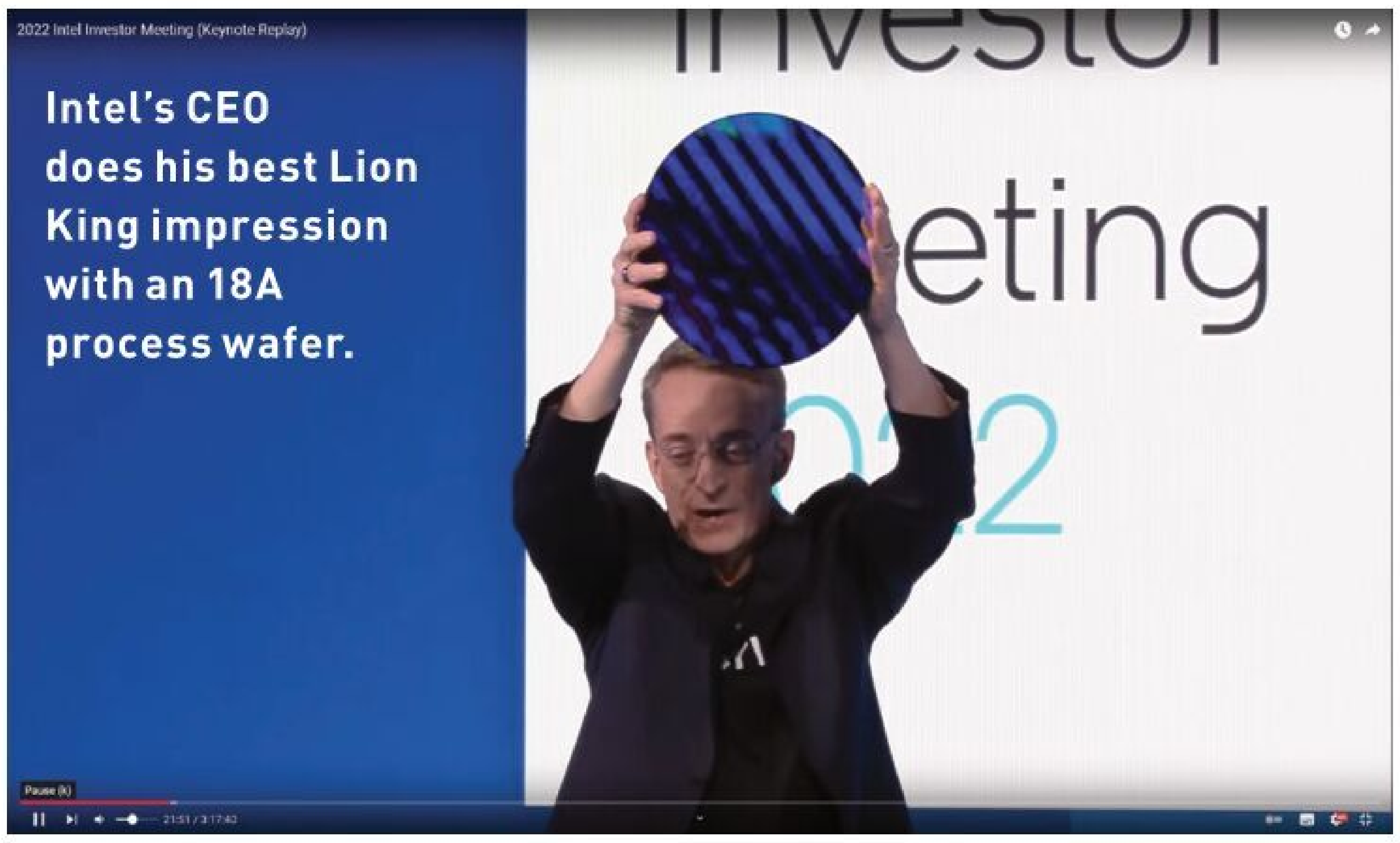
Raptor Lake follows the same hybrid design as Alder Lake, but with up to 24 cores in all—eight performance and 16 efficiency cores, for a total of 32 threads. It will be socket-compatible with Alder Lake, so we won't all have to invest in DDR5 memory at once.

Intel claims Raptor Lake will offer a "double-digit" performance boost for single-thread operations, and more for multi-threaded applications. The top clock rate is expected to be a healthy 5.5GHz and Intel has promised enhanced overclocking features. There's also an optional AI accelerator in the form of an M2 module.

On stage, the engineering sample was given a workout with Blender and Adobe Premiere, designed to show all those cores working away. We can expect those samples to produce the usual round of unofficial leaked benchmarks about now. The chips are due by fall, with the mobile version following later in the year.

Intel claims it is "on track to reclaim performance-per-watt leadership by 2025". The Intel 4 process, using EUV (extreme ultraviolet) lithography could be ready to roll by the second half of the year with Meteor Lake. This should produce another 20 percent bump in performance for the same power. It has Redwood performance cores and Crestmont efficiency cores, integrated AI acceleration, a next-generation graphics engine (currently named tGPU), and a flexible titled architecture similar to AMD's chiplet designs.

After this, the Intel 3 process will be ready by the end of 2023, offering another 18 percent hike with the Arrow Lake chips. Then we enter the Angstrom process. Intel says the 20A process is on track for 2024 for Arrow Lake. Then there's Lunar Lake and the 18A process, also due in 2024.


2022 Intel Investor Meeting (Keynote Replay)
Investor Meeting 2022

Intel's CEO does his best Lion King impression with an 18A process wafer.

Five nodes in four years is impressive, so how has Intel managed to turn it around? Intel's CEO, Pat Gelsinger claims it is by embracing EUV tech, massive investment, and 'deep' partnerships. He says the company stalled at 14nm, but its research teams have now produced the manufacturing capability and techniques it needs.

We didn't hear much on the highly-anticipated Alchemist, Intel's proper entry into the discrete graphics card market. We were supposed to have them in the first quarter, but now it looks as if we'll get a mobile version this summer, and actual desktop cards in the fall. Intel teasers show us high-resolution game images, and we've also seen some leaked photographs of test cards that sport 6-pin and 8-pin power connectors. With room for two 8-pins, it hints at higher power versions to come. Work has started on Celestial, the high-end enthusiast GPU to follow.

Intel appears to be working on a ground-up assault on the graphic card market, with the good news being that all indications are that it will price its cards competitively. Add some encouraging news about servers and cloud business, and Intel's investors have reason to be happy. AMD is currently riding high on a record market share of over 25 percent, but the competition is going to be a lot tougher over the next few years. **–CL**

> “
> Five nodes in four years is impressive, so how has Intel managed to turn it around?

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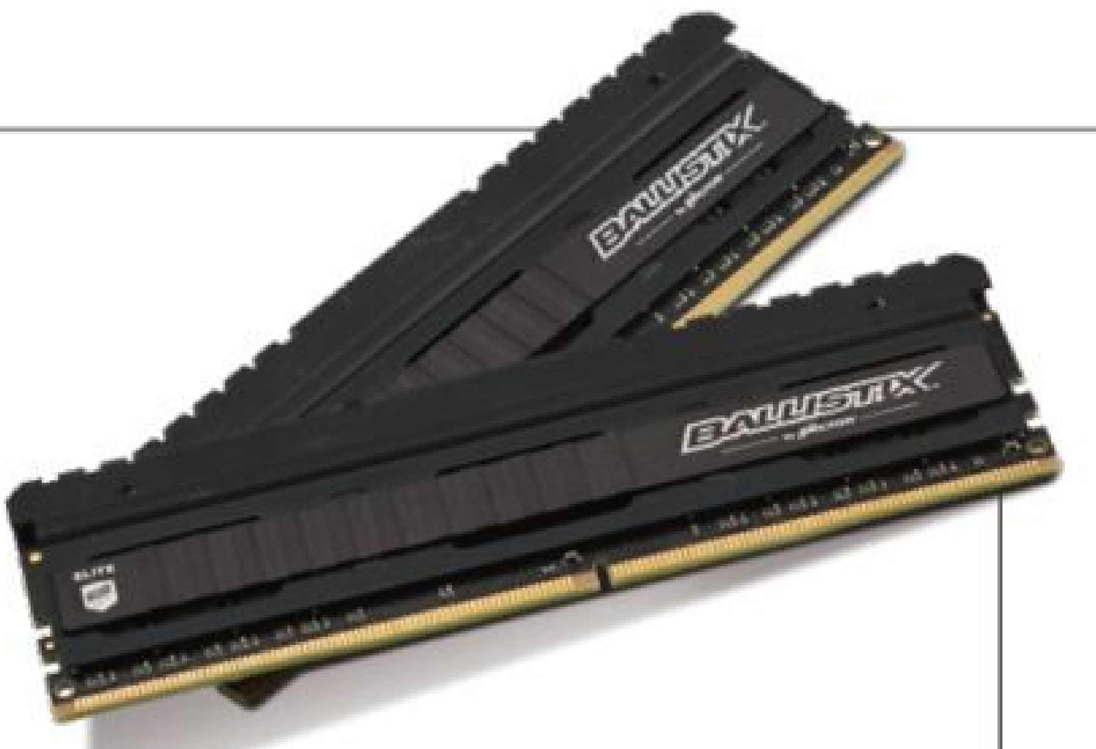
BYE-BYE BALLISTIX

NO MORE ENTHUSIAST MODULES FROM CRUCIAL



GRAB THEM IF YOU CAN, because Crucial Ballistix memory modules have reached the end of the line. Ballistix has long been a favorite of modders, overclockers, and builders of awesome gaming rigs, but now the entire range has been axed, explaining why we've seen no announcements on DDR5 kit to date. Crucial is a consumer brand of Micron Technology, one of the big three with Samsung and Hynix. Why Micron pulled the plug isn't clear, although its statement could give us a clue: "JEDEC standard DDR5 memory provides mainstream gamers with DDR5-enabled computers with better high-speed performance, data transfers, and bandwidth than previously available with Crucial Ballistix memory". It seems that with modern manufacturing methods, pretty much every chip is a good one, and enthusiast memory modules aren't a big enough market. The company will "intensify its focus on the development of Micron's DDR5 client and server product roadmap", and the Crucial brand will live on, selling various SSDs. **–CL**

NO ACCOUNT, NO WINDOWS PRO

Microsoft to insist on authentication

INSTALLING A FRESH copy of Windows 11 Home requires a Microsoft account, and always has done. There is a fiddly and undocumented way to avoid this, but it's not something your average user is likely to know about. It hasn't been a popular move and makes Windows the only major OS that requires an online account to use. That isn't always practical or desired as it makes it a pain to pass on a rig or for third parties to repair it, as you often need to know the account details.

Microsoft has decided to add this restriction to Windows 11 Pro, too. Currently, it's only part of an insider build but it's planned to go live soon. This hasn't gone down well with the typical 'Pro' user, who expects control over their accounts. Not every feature of an insider build goes live, and given enough push-back, Microsoft has been known to back down. We'll just have to see if the company will listen to its customer base on this one. **–CL**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

THE DA VINCI MODE
An engineering team has proven that da Vinci's doodle of an aerial screw helicopter could fly, given modern materials and motors.

BETTER FPS CONTROL
The Alt Avatar Motion Controller aims to replace the keyboard in FPS games with customized analog controls and buttons.

TETRACHROMACY IS REAL
Scientists say tetrachromacy, a term for those who see many more shades of color, does exist.

TRAGEDIES

FAKE QR
The FBI has warned of a growth in scam QR codes that direct the unwary to malicious websites.

FACEBOOK'S FALL
Meta set an unenviable record for the biggest daily fall in stock price by shedding $232bn due to a poor revenue forecast.

LAWFUL STOP
Tesla has recalled 53,822 cars as they'd been programmed to drive through four-way Stop signs if no cars were detected.

DUFF MEMORY INCREASES PRICES

Contamination hits fabs, production binned

A SHARP BUMP in the price of SSD kit will soon make its way down the supply chain thanks to a major 'incident'. Western Digital revealed that, due to an unspecified contamination in the manufacturing process, it has scrapped up to 6.5 exabytes of 3D NAND chips. One exabyte is a billion gigabytes, so that's a lot of lost silicon.

The issue came to light after an inspection of production lines at the two fabrication plants at Yokkaichi and Kitakami in Japan, which are joint ventures between Western Digital and Kioxia. As yet, we don't know officially if Kioxia, which used to be part of Toshiba and is credited with inventing flash memory, has anything significant to add to the losses. It released a statement saying it assumed there were issues with impurities. However, other sources put Kioxia's loss at least as large as the one suffered by Western Digital.

This fab partnership is responsible for about a third of the world's supply of NAND chips so, at a conservative estimate, the contamination has binned 10 percent of the world's modules for the first quarter. This is expected to lead to a price spike of 5 to 10 percent over the summer.

Western Digital has warned that "costs have increased significantly in the short term" and that it will "immediately increase the price of all Flash products". Flash memory had previously escaped the price hikes, as well as the shortages which hit the rest of the semiconductor market.

What exactly was the contamination? We aren't being told. More importantly, why didn't the fabs notice? It takes at least a month to build a 3D memory chip from the base materials, so if you only uncover a problem at the final testing stage, your problem just became a much more significant one. Whatever quality control system was used, it failed spectacularly. We wouldn't want to have to explain this one to our bosses. **–CL**

Western Digital
3D NAND

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NEW BUDGET RTX CARDS

Nvidia follows AMD to 4GB

THE GRAPHICS CARD market is still in a state of upheaval, prices are ridiculous (although thankfully falling), and supplies are tight. Both Nvidia and AMD have had to adjust their designs to match what silicon they can get hold of. Both have released 'budget' cards that weren't on their original roadmaps—and buying any card at the recommended retail price is still basically impossible.

AMD brought us the RX 6500 XT featuring 4GB of VRAM, which was disappointing, and many reviewers have not been kind as a result, including ours (turn to page 80 to see the review). Nvidia's Radeon RTX 3050 has 8GB and has therefore fared better (read our review on page 74). Now it appears that Nvidia will be following AMD's lead by cutting memory to try and get more affordable cards on the shelves.

It reportedly has a 4GB version of its RTX 3050 in the works. It will use a smaller GA107 GPU, rather than the GA106. The provisional specifications are for 2,304 CUDA cores and a base clock of 1,545Hz. The price is expected to be $199, on paper at least. The lower memory should help deter crypto miners as well. There's also talk of another 8GB RTX 3050 design in the works. Getting more cards in the market is good, for sure, but 4GB just isn't enough for a decent gaming rig.

That's what we were told when cards regularly featured 8GB, and AAA games started to expect it. These expedient designs aren't perfect, but they are better than no cards at all. Intel has promised to help, with four million Arc Alchemist cards due before the end of the year. **–CL**

Is HoloLens 3 dead?

WHEN A COMPANY FEELS the need to say a project is "doing great", chances are all is not well, and that seems to be the case for Microsoft's HoloLens project. The company came early to the world of mixed reality in 2016, and while the resulting HoloLens won acclaim, sales have been slow. Microsoft recently partnered with Samsung over future headsets, which has reportedly led to much internal strife, with allegations of in-fighting and staff leaving to join rivals.

Officially, though, HoloLens is "doing great", with Microsoft saying: "don't believe what you read on the internet". There has been one decent sale; last year, the US military signed a $22 billion deal for 120,000 customized HoloLens headsets. Even this is starting to look shaky, with rumored issues about the "quality" of the sets.

Virtual reality, and its augmented and mixed reality cousins, have been the next big things for so long it has become a standing joke. Meta has its metaverse and is working on headsets. Apple is brewing its own hardware, Sony has just dropped its next-generation VR headset, and Google has its Glass project on a back-burner.

If the virtual world takes off, nobody wants to be left behind. The trouble is, it refuses to go mainstream. Last year, 9.8 million headsets were sold, and this year that number is predicted to be 14.2 million. It's growing, but those numbers are still small compared to smartphones and game consoles. That hasn't stopped an awful lot of people betting that there is much more to come, and as Microsoft knows better than anyone, this is a long game with the potential for expensive casualties. **–CL**

11PF
N534SP
13PF
11PF
N534SP
13PF

Microsoft HoloLens looks epic, but securing orders is proving difficult.

Monster board, monster price

MSI has released its MEG Z690 Godlike motherboards. This $2,099 beast is the best Alder Lake board ever, according to MSI. The feature list is impressive, from a 20+2 phase processor power supply with titanium chokes, to six M2 slots, a touchscreen control panel, RGB lighting, black aluminum, and tempered glass.

It's an epic motherboard at an epic price, but buyers also get a free bundle of 32GB Kingston Fury Beast DDR5 RAM, and a CoreLiquid S360 AiO cooler. Buying one isn't easy, production is limited, and you have to register an interest. **–CL**

GODLIKE
GODLIKE

AMD bigger than Intel, briefly

For the first time in its history, AMD was worth more than Intel by market capitalization recently. In mid-February, AMD was worth $197.75 billion, just topping Intel's $197.24 billion valuation. Quite a milestone for the red team.

AMD's stock received a huge bump on completion of its $49 billion acquisition of the fabless chip company Xilinx (creators of the first commercial field-programmable gate array). This deal added 428 million new AMD shares to the existing 1.2 billion.

Meanwhile, Intel's stock slipped, allowing AMD to pull into the lead. It may have only been temporary, but the market noticed. In the summer of 2020, AMD was worth just a seventh of Intel. **–CL**

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Jarred Walton

TECH TALK

Big Fish Intel Enters the Mining Pool

PERHAPS A SIGN of the coming cryptapocalypse, Intel recently disclosed that it has been testing the waters for mining ASICs for years. It also revealed its first-generation BMZ1, codenamed Bonanza Mining, and looked ahead to BMZ2, its second-generation chip that will be manufactured on a cutting-edge node rather than the 14nm process used for BMZ1. Most surprisingly, it was noted that BMZ1 was created as a 'product exploration' in 2018.

To recap, Bitcoin peaked at over $19,000 in late 2017, then dropped to around $4,000 by the end of 2018. Bitcoin prices fluctuated in the $4,000–$12,000 range until the latest surge in prices in 2020. Bitcoin passed the $20,000 mark in December 2020 and hasn't looked back, with prices ranging from a low of $33,000 to a high of $65,000—though by the time you read this, it might have exceeded either of those boundaries. That volatility perhaps kept Intel from seriously pursuing mining at the time, but now it's ready to dip its toe into the waters.

The initial BMZ1 foray into cryptocurrency mining took a similar approach to other Bitcoin ASICs, packing about 137 GH/s of SHA-256 hashing power into a chip that measured just 14.2mm^2. That tiny die size means Intel could get around 4,000 chips from a single 300mm silicon wafer. While the hashrate of a single chip is nothing special, modern Bitcoin miners use hundreds of chips placed on larger circuit boards. BMZ1 already delivered an efficiency rating of 18.2 W/TH, which compares favorably to Bitmain's S19 Pro ASIC with an efficiency of 29.5 W/TH. How BMZ1 would scale to larger mining solutions isn't clear, but considering the S19 Pro uses TSMC's N7 process, the fact Intel delivered higher efficiency using its 14nm node suggests Bitmain and other ASIC companies should be worried.

It's not just the performance, of course. One of the big issues with mining ASICs is their prohibitively long lead times, and the fact that companies such as Bitmain and MicroBT often change prices according to the current value of Bitcoin. Since they are smaller players in the global chip market, competing for wafers at TSMC and other foundries, supply can be a bit less predictable. Intel owns a lot of chip fabs and has much higher volumes from its CPUs. It could put out a lot of 14nm BMZ1 chips and conceivably offer better pricing to big mining firms.

That appears to be the path forward, as one large mining firm, GRIID Infrastructure, has apparently inked a contract where it will purchase 25 percent of Intel's mining ASICs through 2025, with fixed pricing through 2023. GRIID has plans to go public with an initial estimated valuation of $3.3 billion, and it intends to operate three mining facilities totaling 734 megawatts of power by 2023. Other mining firms that will use Intel's chips include Argo Blockchain and BLOCK (formerly known as Square).

Intel's BMZ1 chip, codenamed Bonanza Mining, is optimized for Bitcoin's SHA-256 algorithm.

© INTEL

Intel hasn't said exactly what we can expect from BMZ2, but rumors are it will use TSMC's N5 process. Assuming a similar chip size to BMZ1, it could potentially double the hashing power within similar power constraints. But Intel's competitors aren't sitting still. There are already rumors of Bitmain's S19 XP, using TSMC N5 too. Except, it's said that S19 XP will only reach an efficiency level of 21.5 W/TH, something Intel already does on its own 14nm node.

Intel's Raja Koduri, head of the Accelerated Computing and Graphics Business Unit, wrote about the emerging importance of blockchain technologies. "We are declaring our intent to contribute to the development of blockchain technologies, with a roadmap of energy-efficient accelerators. Intel will engage and promote an open and secure blockchain ecosystem and help advance this technology in a responsible and sustainable way." If you were hoping blockchain and mining would fade away, that's not likely to happen any time soon. Let's just hope more of it migrates away from using graphics cards.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

THE LIST

THE TOP FIVE TKL GAMING KEYBOARDS

With respect to all the accountants and spreadsheet wizards out there who couldn't live without their numerical keypads, most gamers find them an unwelcome distraction between the main keys and the mouse. That's why tenkeyless (also known as TKL) keyboards have become so popular recently, especially for those with limited desk space. So, this issue's list focuses on five of our favorite TKL keyboards, aimed at gamers looking for the perfect compact setup.

5

STEELSERIES APEX 3 TKL

The only non-mechanical keyboard on this list, the SteelSeries is still a fantastic board with lots of features. We love SteelSeries' "Whisper-Quiet" switches that feel great to type on, the dedicated media controls, and PrismSync lighting control, but we don't love the non-removable USB cable. SteelSeries also claims the Apex 3 TKL is the world's first water-resistant TKL keyboard. **$45, steelseries.com**

4

ASUS ROG STRIX SCOPE TKL DELUXE

This Asus uses the popular Cherry MX Red switches. It scores points for having a larger CTRL key for FPS players, a newer-style USB-C connector, and a magnetic wrist-rest included, but it loses out for its lack of dedicated media controls and the overly stylized font on the keys. It also works with Aura Sync and has under-keyboard lighting. **$100, rog.asus.com**

3

CORSAIR K70 RGB TKL

Available with either Cherry MX Red or Cherry MX Speed switches, the K70 RGB TKL boasts the build quality we've come to expect from Corsair. It syncs with the company's iCue lighting controls and has a switch to enable static lighting so you can focus on your games. **$100, corsair.com**

2

MSI VIGOR GK50 LOW PROFILE TKL

If you like mechanical keyboards but find them difficult to type on, this is ideal. The keys are lower and wider, making it feel more like a laptop keyboard, although the Kailh Low Profile mechanical switches are "clicky" and therefore noisy. At 560g, it also weighs much less than its rivals, making it well suited for travel in its included carry case. **$100, msi.com**

1

LOGITECH PRO TENKEYLESS GAMING KEYBOARD

Logitech's compact board is a great all-rounder, with features such as button-based lighting control and a game mode button to disable the Windows and Menu keys while gaming. If Logitech's Blue "clicky" switches are an issue, the Pro X model costs $30 more and lets you swap out switch types. **$100, www.logitechg.com**

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Jeremy Laird

TRADE CHAT

18 months of awesomeness

NOT LONG AGO, it was fashionable to write snarky, knowing obituaries to the PC. Tiring, redundant, past its best… the personal computer's fate was assumed to be death by a million tiny cuts. The culprits? Smartphones, tablets, thin clients, you name it, anything that's not actually a PC. I mean, who wants to TikChat their Facegram flunkies on a clunky old beige box?

At least, that was the usual refrain. Not only did it never happen, but if anything the PC is in ruder health than it's ever been. What's more, the next 18 months or so are set to be even more special. A rapid-fire product assault is coming from AMD, Intel, and Nvidia, the likes of which we've never seen. Arguably it all started in 2014 when Lisa Su took over AMD and set about knocking PC hardware's perennial underperformer into shape. AMD's renaissance has forced Intel and Nvidia to up their game and PC enthusiasts are set to benefit.

On the PC processor side, Intel will follow up the impressive Alder Lake architecture with Raptor Lake later this year. There's a chance it might arrive less than a year after Alder Lake and bring with it another big leap in performance, comparable to the boost Alder Lake delivered over the disappointing Rocket Lake family. Then, in the first half of 2023—again, under a year after Raptor Lake—Intel hopes to roll out another new architecture in Meteor Lake. Critically, this is no incremental overhaul. Instead, it will be the first CPU architecture based on the new Intel 4 process node.

As for AMD, the latest rumors suggest it may release Zen 4-based Ryzen 7000 chips as early as August this year. Zen 4 is expected to be a big step up on existing Zen 3 processors thanks to an enhanced architecture, TSMC's 5nm technology, and 5GHz-plus clock speeds. Even better, Zen 5 could follow Zen 4 in less than a year, bringing with it even more performance. In other words, it's going to be a spectacular fight between Intel and AMD for CPU dominance with a combined total of four new families of chips in the next 18 months.

> In the next year, it's going to be a spectacular fight between Intel and AMD for CPU dominance.

Intel's Arc graphics should ease the gaming GPU supply shortage.

© INTEL

If that wasn't enough, the graphics market will see almost as much action. Of course, it's not exactly news that the big boys of GPUs, Nvidia, and AMD, are tooling up new graphics architectures. After all, both AMD's RDNA 2 and Nvidia's Ampere chips are over a year old. But if the rumors are to be believed, AMD RDNA 3 and Nvidia Lovelace, otherwise known as the Radeon RX 7000 Series and GeForce RTX 40 Series respectively, are set to bring huge leaps in performance.

AMD is widely reported to be going with a radical multi-chip approach with RDNA 3, while Nvidia's Lovelace will benefit from a shift from Samsung's arguably underwhelming 8nm production process to TSMC's cutting edge 5nm node. All told, don't be surprised if certain GPUs in the new product stacks deliver double the performance of the chips they replace. RDNA 3 and Lovelace could be that spectacular. Both are due before the end of this year.

Before that, however, is Intel's new Arc graphics, Chipzilla's first real attempt at modern gaming graphics. Nobody is expecting Intel to blow the competition away immediately but the smart money says the fastest of the first generation of Arc GPUs will be a match for Nvidia's RTX 3070 chipset, giving gamers an option in the mid- and upper mid-range. What's more, Intel says it plans to ship at least four million gaming graphics cards in 2022.

Given that AMD and Nvidia sell a combined 10 to 15 million GPUs per quarter, that's not quite as big a number as it first seems. But those GPUs will be largely back-loaded into the latter half of this year. So, they should make a dent in the supply-side issue that's been pushing GPU pricing to such insane levels of late.

Speaking of which, the signs are that the GPU market is finally beginning to normalize. It won't happen overnight. But sticking with that 18-month time frame, a return to something resembling affordability is plausible. I can't remember the last time things looked so promising for the PC.

Six raw 4K panels for breakfast, laced with extract of x86… Jeremy Laird eats and breathes PC technology.

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> Dead PC?
> Win11 update error
> TPM 2.0 upgrade

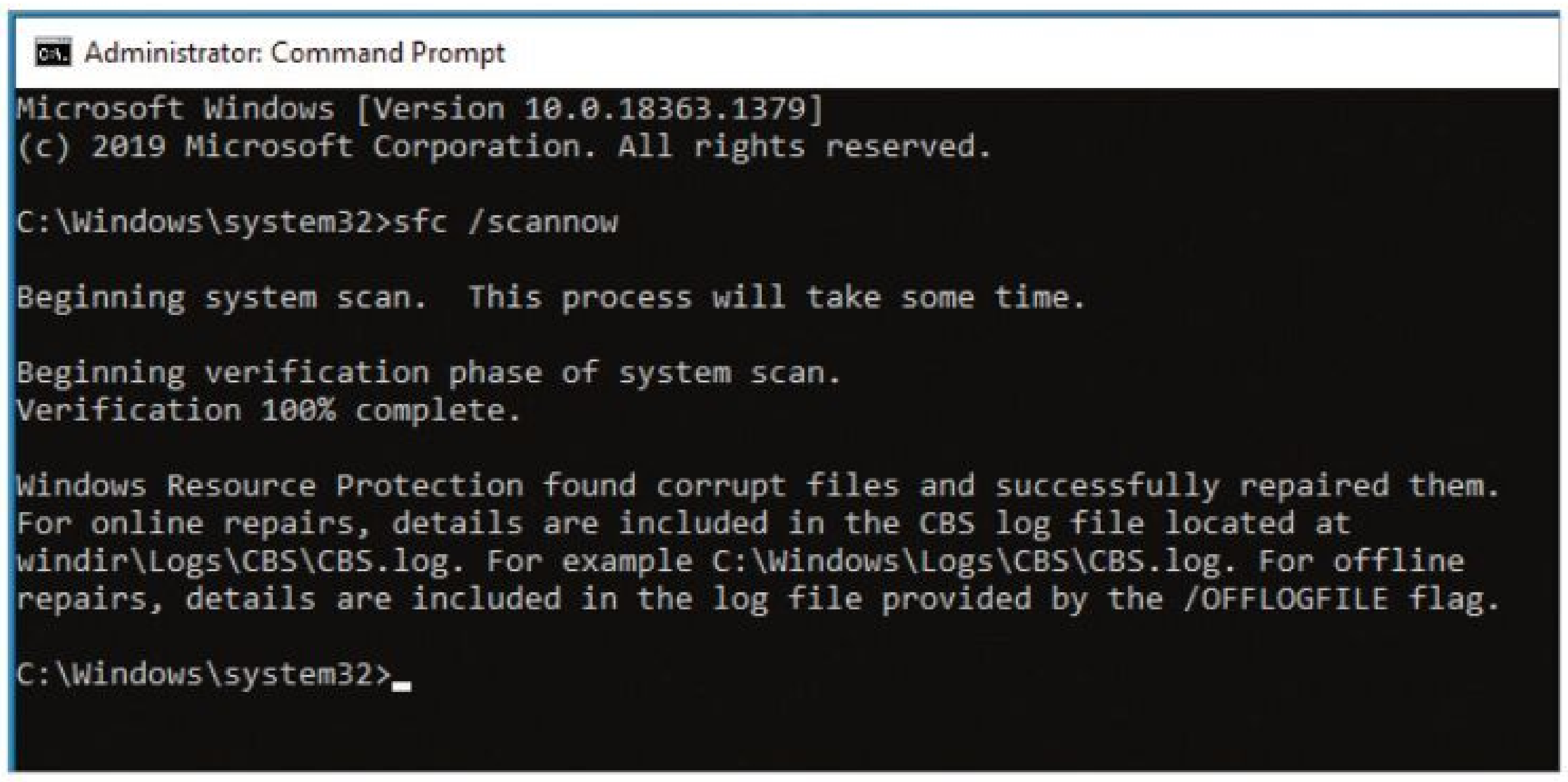
PC won't post to BIOS

I've had my computer since 2013: Intel i5-4670K, Gigabyte GA-Z87X-UDH3, 16GB Corsair Vengeance DDR3 1600MHz RAM (two 8GB sticks), housed in a Thermaltake case and powered by a CX Series 80 Plus Bronze CPU. When I try to boot, the PC turns on for about two seconds, then turns off and tries to reboot without success. I can't even get into the BIOS.

I've switched out the power supply, tried only one stick of memory, and switched out the CPU cooler to no avail. I suspect the motherboard is at fault, but nothing obvious shows on the board. Your advice would be appreciated.

—Paul LoGrasso

THE DOCTOR RESPONDS: Assuming you've already stripped the machine back to its core—booting with all non-essential external peripherals and internal components (including drives and expansion cards) disconnected, the lack of any LED debug codes to offer even a hint of what might be going wrong does suggest the motherboard has reached the end of its life.



```
Microsoft Windows [Version 10.0.18363.1379]
(c) 2019 Microsoft Corporation. All rights reserved.

C:\Windows\system32>sfc /scannow

Beginning system scan.  This process will take some time.

Beginning verification phase of system scan.
Verification 100% complete.

Windows Resource Protection found corrupt files and successfully repaired them.
For online repairs, details are included in the CBS log file located at
windir\Logs\CBS\CBS.log. For example C:\Windows\Logs\CBS\CBS.log. For offline
repairs, details are included in the log file provided by the /OFFLOGFILE flag.

C:\Windows\system32>_
```

Try running SFC to fix update issues.

You could try dismantling and rebuilding from scratch. This would enable you to inspect each component and put them back in place. Make sure the case is clean and, after rebuilding the minimum required to boot, try again. It's a long shot, but it may fix problems caused by chip creep, loose screws (like short circuits), and other mechanical faults.

Windows Update error

I'm trying to prep an old laptop for a Windows 11 upgrade. It's compatible, but I've not used it in so long that when I go to Windows Update it tells me the current version has reached end of service. I try to update to the latest one offered (20H2), but it fails with error code 0xc190012e. **—John Gannon**

THE DOCTOR RESPONDS: There are many causes of this problem, but one clear path to follow in trying to resolve it. First, we asked John to remove his third-party security software (McAfee), switch to 'Settings → Update & Security → Troubleshoot', and click 'Run the troubleshooter' under Windows Update. It detected problems and invited John to retry the update, but it failed again. He ran sfc /scannow, which found errors and was able to fix them, but still the update refused to budge.

We switched our attention to the Windows Update Assistant. As Windows 11 requires version 2004 or later, John first had to go to www.microsoft.com/software-download/windows10 and click 'Update now' to download and run the Windows 10 Update Assistant. However, this got a different error: "There was a problem running preinstall.cmd scripts".

At this point, we consulted with John who confirmed there was nothing on the laptop worth keeping, so rather than wrestling with this failing Windows 10 installation, we went straight to Windows 11. John had already confirmed his laptop was compatible using the Windows 11 PC Health Check App (https://aka.ms/GetPCHealthCheckApp)—third-party alternatives, such as WhyNotWin11 (https://github.com/rcmaehl/WhyNotWin11), will give a more detailed explanation. Subsequently, it was a case of directing him to download the Create Windows 11 Installation Media Tool (https://www.microsoft.com/software-download/windows11) to create a bootable USB flash drive, then install Windows 11 fresh from that. Skip the request for a product key during installation—Windows will upgrade the laptop's Windows 10 digital license during activation.

© MICROSOFT

↘ submit your questions to: doctor@maximumpc.com

Saving old PCs

Hi Doc, I had a Ryzen 5 2400G running on a Gigabyte Aorus B450 Pro Wi-Fi, with 32GB RAM and 500GB Samsung EVO M.2 NVMe boot drive plus 2TB hard drive that I built two years ago. I was running the Windows 11 Pro Insider Preview (Dev channel) when I discovered the Ryzen wasn't compatible with Windows 11 due to the well-known TPM issue, so I purchased a Ryzen 7 5700G. I had to update the BIOS and do a clean reinstall but am now running a great system with no problems. I will have to build a new system for my wife because her system isn't compatible, despite running Windows 10.

I have been repairing older computers to be donated to senior groups in need and it's too bad that these computers will soon be bricks because of TPM. It's simply hard luck on those who can't afford a new box. **—Rick G**

THE DOCTOR RESPONDS: Did you know that TPM 2.0 can be added to many systems even when the CPU itself doesn't support it? That's because TPM can be rendered one of two ways: through the CPU's own firmware, or through a discrete module on the motherboard itself. Even if your CPU fails the TPM check, all may not be lost.

Many motherboards come with a header for connecting plug-in TPM modules (check your mobo manual), enabling you to render TPM support directly from the mobo. There's no standard header, so you'll probably need to source the TPM module from your mobo manufacturer.

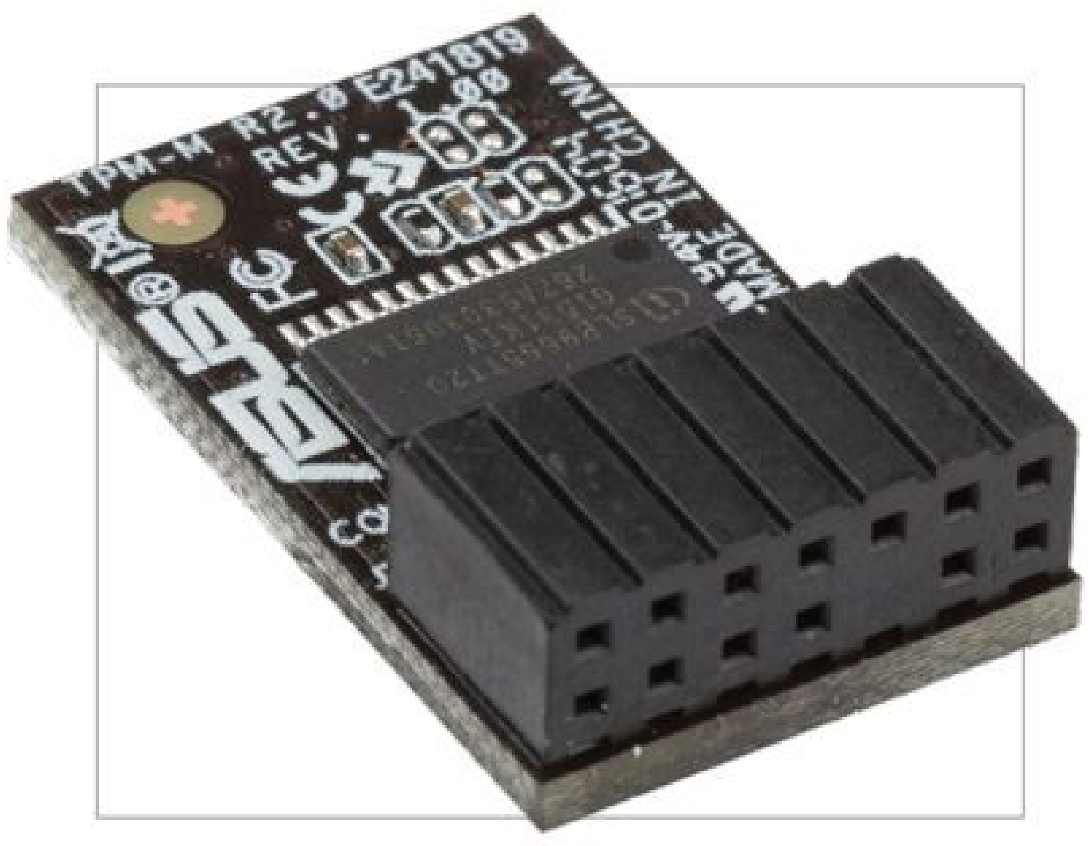
Originally available for $20, the value of these chips soared on the back of the original announcement that Windows 11 would require TPM 2.0 support. Taking Rick's PC as an example, his Gigabyte Aorus B450 Pro board supports the Gigabyte GC-TPM2.0 module. At the time of writing, newegg.com sells these for $80, but you'll find much cheaper 'compatible' modules from third-party manufacturers on eBay that ship direct from China for as little as $15. Take care when buying these—some offer chips for multiple manufacturers within a single listing, so select the correct one. Look for listings that provide detailed descriptions and pin diagrams to help you pick the correct module.

For those PCs locked out of Windows 11, Windows 10 will continue to be supported until 2025, which buys a little time for those without the funds to buy a new box. Should you be desperate to move to the newer version, you can bypass this check for now (see the following question) but the Doc also wonders if now isn't the right time to take another look at Linux. There are some great user-friendly distros out there to tempt you away—Ubuntu, Mint, Elementary, and Deepin Linux to name but four.

Virtualizing TPM 2.0

In your response to Morris Pomey's question ('Boot Camp Updates', Holiday 2021 issue) you indicate that Parallels "creates a 'virtual' TPM chip to meet the Windows 11 TPM 2.0 requirement". This confirms my theory that Microsoft could create virtual TPM 2.0 functionality to allow Windows 11 to run on older hardware. Performance might be slower, but I doubt that chip is being pounded every microsecond. Or am I inferring too much from the statement? **—Gary Lavery**

THE DOCTOR RESPONDS: The Doc's cynical side says if this were possible, it would have already happened. The TPM 2.0 requirement was a deliberate choice by Microsoft to lock out older hardware. This is shown by the fact Windows 11 can run on machines without the TPM 2.0 chip by instructing Windows to skip the TPM check through a Registry tweak. This can be applied whether you're planning to upgrade an existing Windows 10 installation or do a clean install.


Many mobos support TPM2.0 directly.

© ASUS

In both cases, it's carried out through an administrative command prompt—if you're upgrading Windows, type 'cmd' into the Search tool and click the option to 'Run as Administrator'. If you're using installation media to perform a clean install, follow the setup wizard to the point where you're told your PC has failed the upgrade check, then press Ctrl + F10 to open a command prompt window, then type the following command and press Enter:

```
REG ADD HKLM\
SYSTEM\Setup\LabConfig
/v BypassTPMCheck /t
REG_DWORD /d 1
```

Upgraders can now launch the update through Windows, while those opting for a clean install should close the command prompt, then click Back in the install wizard before proceeding as normal. The issue with this workaround is that there's no guarantee it'll work forever. What's to stop Microsoft from closing the loophole or blocking updates to systems where no TPM 2.0 chip has been detected?

The irony is that you can run Windows 11 in a virtual environment on systems that fail the TPM 2.0 check—that's true for Microsoft's own Hyper-V virtualization solution that ships with Windows 10 Pro.

If this approach appeals, then when creating your virtual machine with Hyper-V, select 'Generation 2' at the 'Specify Generation' screen. After the VM has been set up, open its settings to the Security section, where you should enable Secure Boot, select Microsoft Windows from the Template dropdown, and tick 'Enable Trusted Platform Module' before clicking OK.

Insider Prisoner

Little did I know when I signed up for Windows Insider Preview that along would come Windows 11. I'm running Windows 10 Pro on an HP Z800 that can't run Windows 11 but, as Windows Preview tries to install Win11, I keep getting, "This build of Windows will expire soon".

Is there any way I can get back on track without having to jump through the backup and reinstall Windows 10 Pro circus? **—Frank D Gunseor**

THE DOCTOR RESPONDS: It appears you're running on the Dev channel of Windows Insider—confirm this by going to Settings → Update & Security → Windows Insider Program. If you're on Release Preview or Beta channel, you could switch this off and revert to regular Windows 10 updates from the next major release (22H2, due later this year).

The fact you're receiving this message suggests otherwise—had you been in the Beta channel, Microsoft would have moved you to the Release Preview channel when your laptop failed to meet the requirements.

So, you'll need to make a backup and then download the latest Windows Media Creation tool (www.microsoft.com/software-download/windows10) to create the Windows 10 installation media you'll need to wipe your system drive clean and install a fresh copy of Windows from scratch. ⏻

$1300 12TH GEN DELIGHT

What can we get from Intel's 12th-gen mid-range chip?

FROM INTEL'S NEW 12th-generation line-up of chips, the i5-12400 doesn't initially appear to be the pick of the bunch. Following our recent i9-12900K build, it doesn't quite have the credentials to match that model. But does it have enough oomph to push out solid 1080p gaming with the sliders cranked up? Building inside Corsair's impressive 275R Airflow case should help show it off—we may be overdoing the white cases of late, but we've had some slick ones we just couldn't ignore.

For this build, we have more than doubled our previous $600 budget. With the bar now set at $1300, we are looking for the best performance we can get from one of Intel's latest budget CPUs. We also have some cash spare for a fairly decent GPU, so we have opted for the RTX 3050, which matched up well in the mid to high-end budget range.

Choosing parts is always the most time-intensive section of any build. With so many different combinations of components, there are an almost endless amount of possibilities. Of course, we have to check for compatibility which isn't always as simple as checking PC Part Picker, and we also have to stick to our budget. This is always a challenge as most builds have these two targets in mind.

So, with a 12th-gen processor, a capable GPU, a Corsair case, and the rest of the $1300 budget to play with, this should be an intriguing build. Hopefully, at the end of it all, we should be left with some comfortable numbers and a 1080p gaming beast.

INGREDIENTS

PART		RRP/STREET PRICE
CPU	Intel Core i5-12400	$209
CPU Cooler	Noctua NH-U12S redux 70.75 CFM	$50
GPU	Gigabyte GeForce RTX 3050 GAMING OC 8GB GDDR6	$380/ $560
Mobo	MSI MAG Z690 TOMAHAWK WIFI DDR4 ATX	$292
RAM	16GB (2x8GB) Corsair Vengeance RGB RS DDR4-3200 CL16	$78
OS Storage	Samsung 980 1TB M.2 SSD	$110
PSU	Corsair RM 750 80+Gold PSU	$98
Case	Corsair 275R Airflow ATX Mid Tower Case	$90
TOTAL		**$1307 / $1487**

PRICES CORRECT AT THE TIME OF PRINTING

BUILD IT PG.21

GEFORCE RTX
GIGABYTE

CPU

INTEL CORE I5-12400

RRP: $209

This six-core chip is an interesting pickup for around $200. Unlike the beastly i9-12900k we featured in a recent rig, this chip doesn't follow the same hybrid efficient architecture and all of its cores are performance-focused.

However it does have 12 threads and a max turbo frequency of 4.40 GHz, but where this shines is in its overclocking performance. Unfortunately, we won't be benching this with the added benefit of overclocking, but it's some peace of mind. Right now, it is one of the best budget CPUs out there and, considering it's the 12th generation in Intel's lineup, it should be pretty good for future-proofing and a great brain for our setup. ***intel.com***

CPU COOLER

NOCTUA NH-U12S REDUX

RRP: $50

To keep things cool, we chose Noctua's NH-U12S Redux. This budget-friendly variant of the popular NH-U12S has almost been around for a year and at $50, it's still a great option. Compared with the standard NH-U12S, it has a different fan and one fewer heat pipe than its bigger sibling. With LGA1700 compatibility for our 12th-gen processor and enough clearance for the RAM, this was a logical cooler. We prefer the gray-colored fan to the standard NH-U12S, so that's a bonus. *noctua.at*

GPU

GIGABYTE GEFORCE RTX 3050 GAMING OC 8GB

RRP: $379.99 / STREET PRICE: $559.99

The RTX 3050 is the entry point for the 30 series but that shouldn't be seen in a negative light. This Gigabyte Gaming OC model packs slightly higher clock speeds than non-OC variants and with 8GB of GDDR6, it should be more than enough to play 1080p titles at high frame rates. It should even be able to sneak into QHD territory.

As one of the easiest 30 series cards to get hold of, it's a popular card and we are excited to test it out with our budget-end 12th-gen chip behind the wheel. *gigabyte.com*

GIGABYTE
GIGABYTE
GIGABYTE

MEMORY

16GB (2X8GB) CORSAIR VENGEANCE RGB RS DDR4-3200

RRP: $78

As our board has no supported RGB, we thought we'd add a bit of color to the mix with these Corsair Vengeance RGB sticks. 16GB is more than enough RAM for our spec and the design fits in nicely with the motherboard.

It would have been nice to get our hands on some faster 3600 MHz sticks and a set of four to fill out the mobo, but this will be capable of getting some solid processing performance out of this build. ***corsair.com***

STORAGE

SAMSUNG 980 1TB M.2 SSD

RRP: $110

Unlike the more expensive Pro variant, this SSD doesn't have PCIe 4.0 support and sticks to PCIe 3.0. However, with a 1TB capacity, it's still a fine addition to our system. We could have chosen the 970 Evo but our model has faster read and write speeds. *samsung.com*

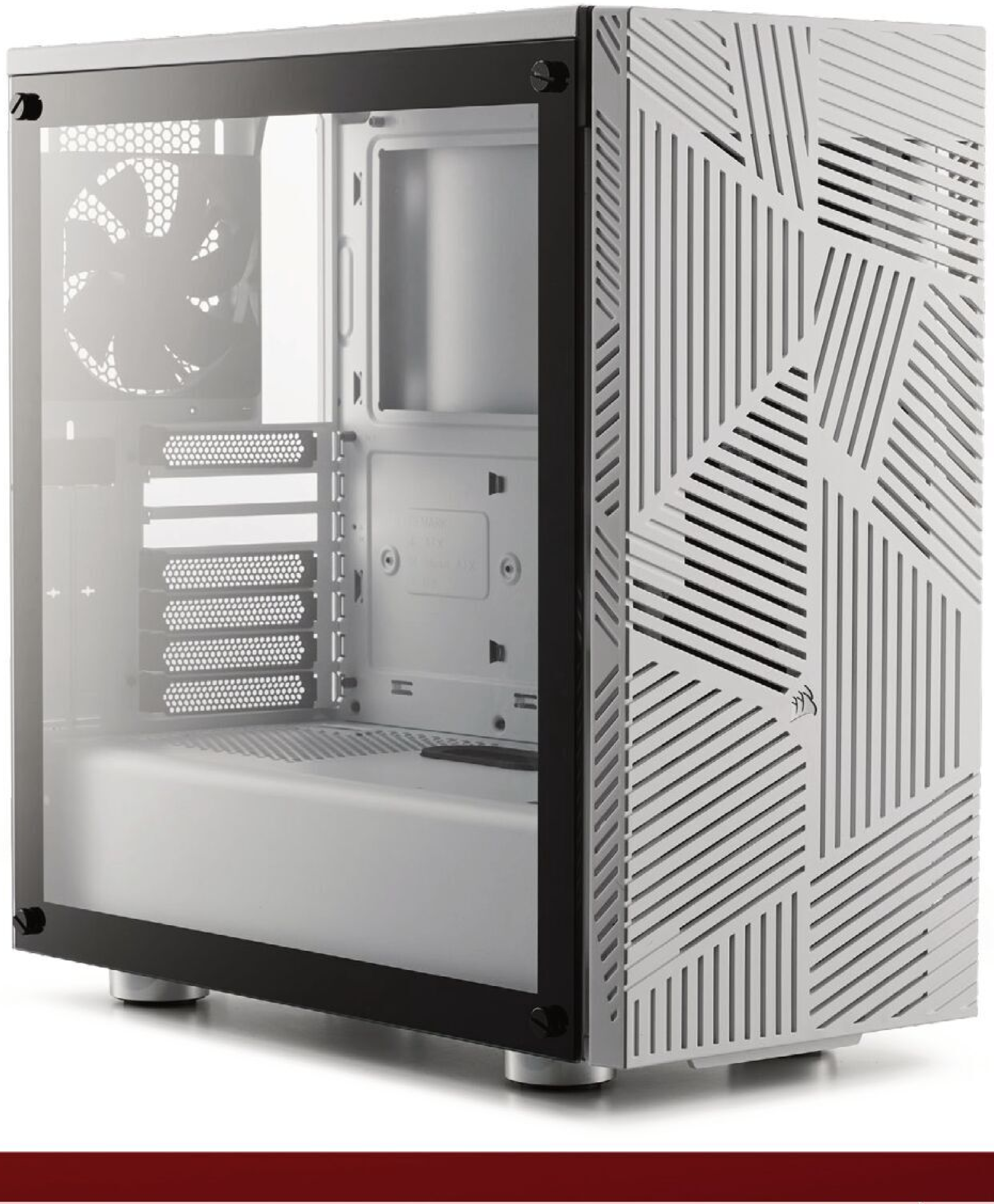
CASE

CORSAIR 275R AIRFLOW ATX MID TOWER **RRP: $90**

Housing all of our glorious components is this tasty-looking case from Corsair. The 275 Airflow is a great sub-$100 dollar case that has some bold styling cues.

We have to mention the front panel of this case first, that patterned grill gives us 1990s soccer kit vibes and personally, we are huge fans. The criss-cross grill should allow the case to have good ventilation whilst also making it stand out from the crowd.

Talking of standing, it is also raised higher off the ground than most cases, thanks to its tall chrome feet. Unfortunately, there is no USB-C, so we will have to rely on the motherboard to provide this. ***corsair.com***



RM750X
CORSAIR

PSU

CORSAIR RM 750 80+GOLD PSU **RRP: $98**

This Corsair RM unit has a respectable 80+ Gold rating to ensure a high level of efficiency and a quiet fan means it will be nice and subtle in our build. As it's modular too, we can only use the necessary connections we need to keep on top of cable management, nobody has time for messy cables, especially when they aren't being used. It's not the cheapest PSU but, at 750W, it is powerful enough to keep all of our components running at optimum. In fact, it's probably more than we need, even with our RTX 3050 GPU powering away. *corsair.com*

MOTHERBOARD

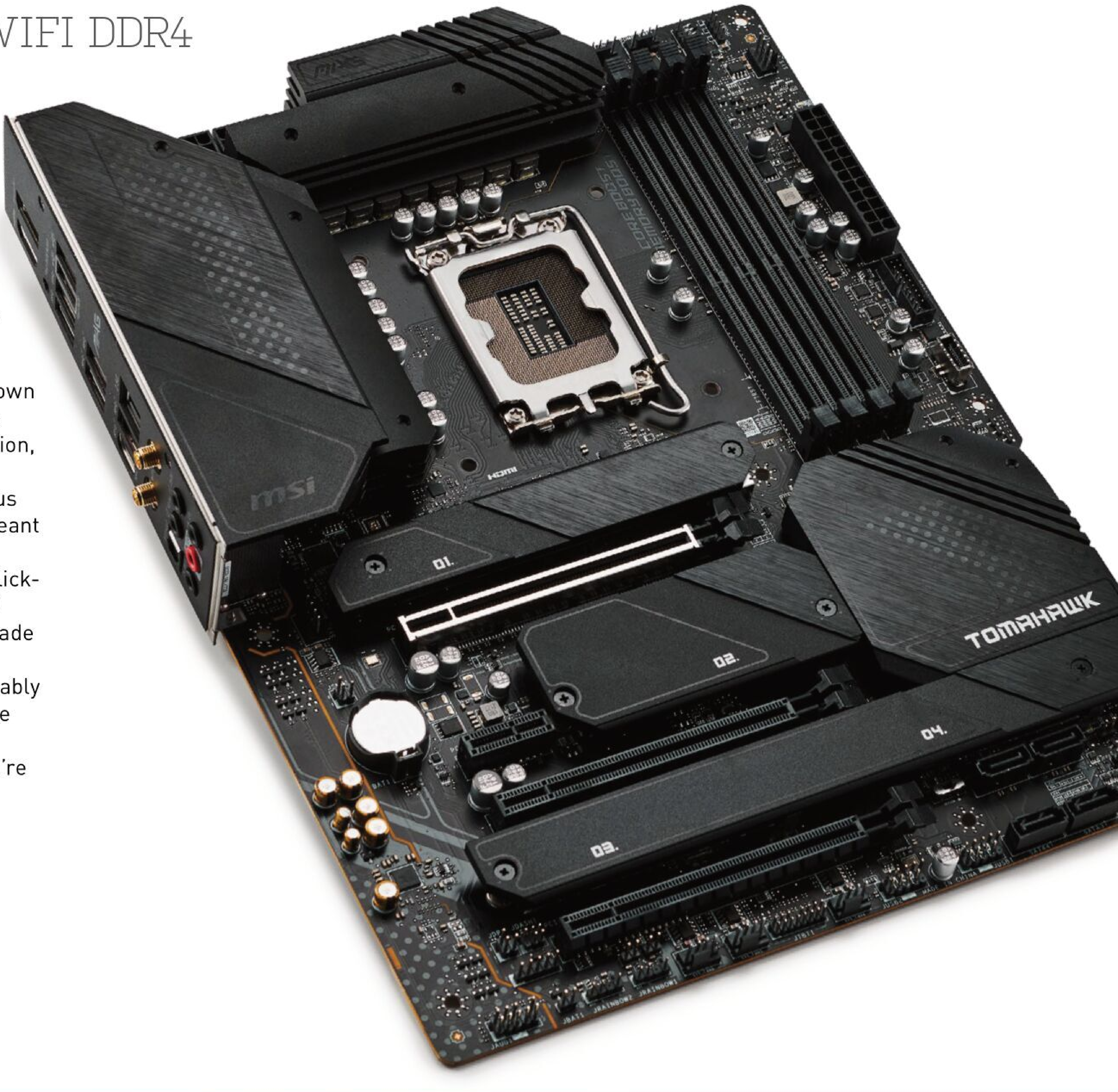
MSI MAG Z690 TOMAHAWK WIFI DDR4

RRP: $292

Of course, with our 12th-gen chip, we needed to get a Z690 board with the compatible LGA1700 socket to go along with it. This can make the leap to the new Alder Lake chips more of a difficult choice, as you will have to dig even deeper into your wallets.

For this build, we didn't go down the route of DDR5, as it's still in the early stages of its introduction, prices are sky high and performance isn't yet swaying us in comparison to DDR4. This meant we could use MSI's MAG Z690 TOMAHAWK WIFI DDR4. This slick-looking board gives us PCIe 5.0 support, a very welcomed upgrade over the Z590 TOMAHAWK.

For a Z690 board, it's reasonably priced and a strong board to use with plenty of futureproofing. Although if you're into RGB, you're out of luck here. ***msi.com***



12TH-GEN DELIGHT BUILD

Can this 12th-gen rig power you to 1080p gaming joy?

LENGTH OF TIME: **1-2 HOURS**
LEVEL OF DIFFICULTY: **EASY**

GEFORCE RTX
GIGABYTE

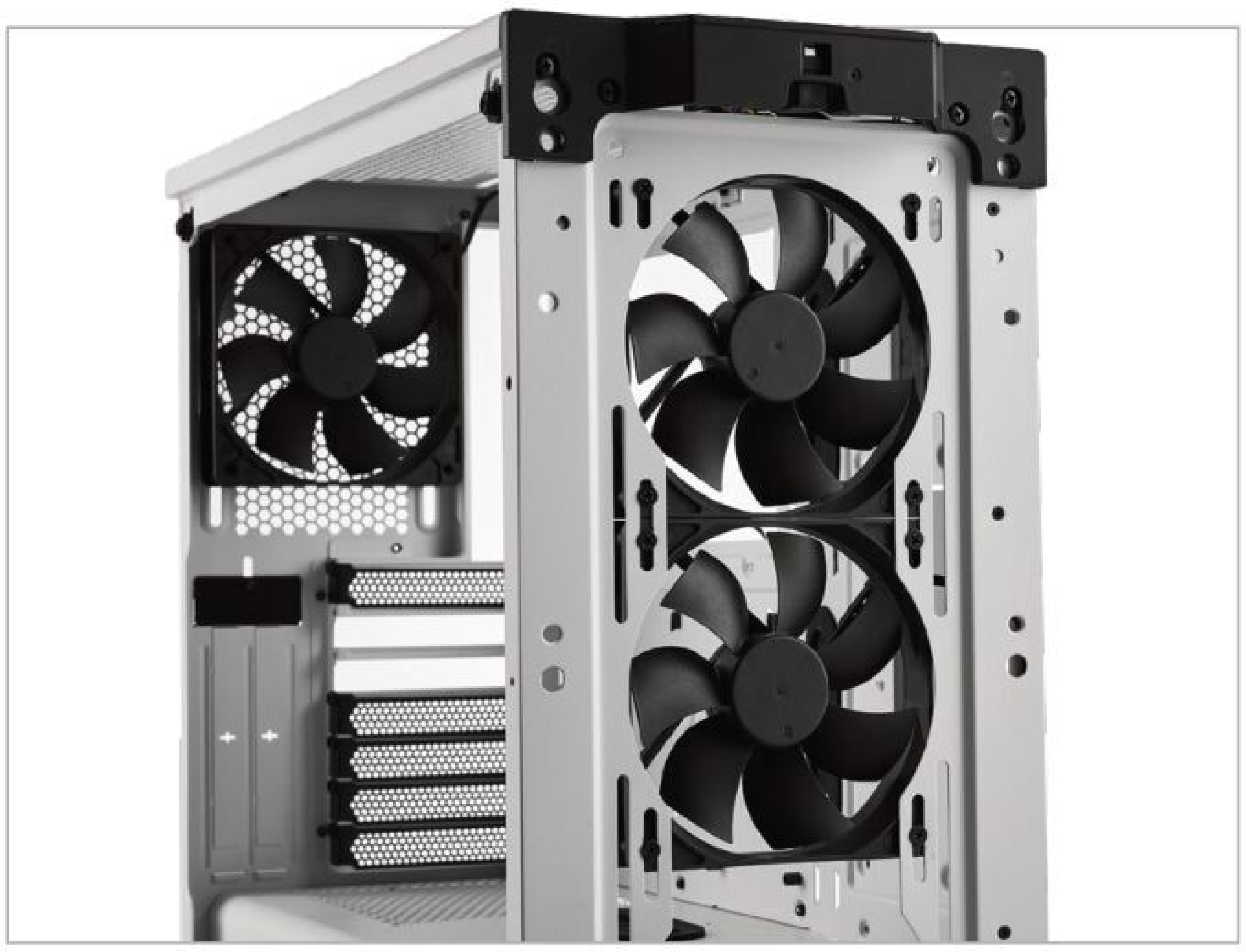
1 BACK TO BASICS

WE HAVE ANOTHER sweet-looking chassis to play with for this build. Thankfully, it's a light case with many avenues to thread cables through. We remove both the front and back panels, top mesh filter, front grille, front filter, and case fans. Sounds like a heavy task but most of these are secured with thumbscrews and require a screwdriver at most.

We recommend resting the case down on its back when taking the front glass panel off to avoid dropping it. If we said we haven't had accidents with glass panels, we'd be lying. Anyway, with just the Corsair's 275R Airflow's skeleton on show, we can get started on adding in the goodies.

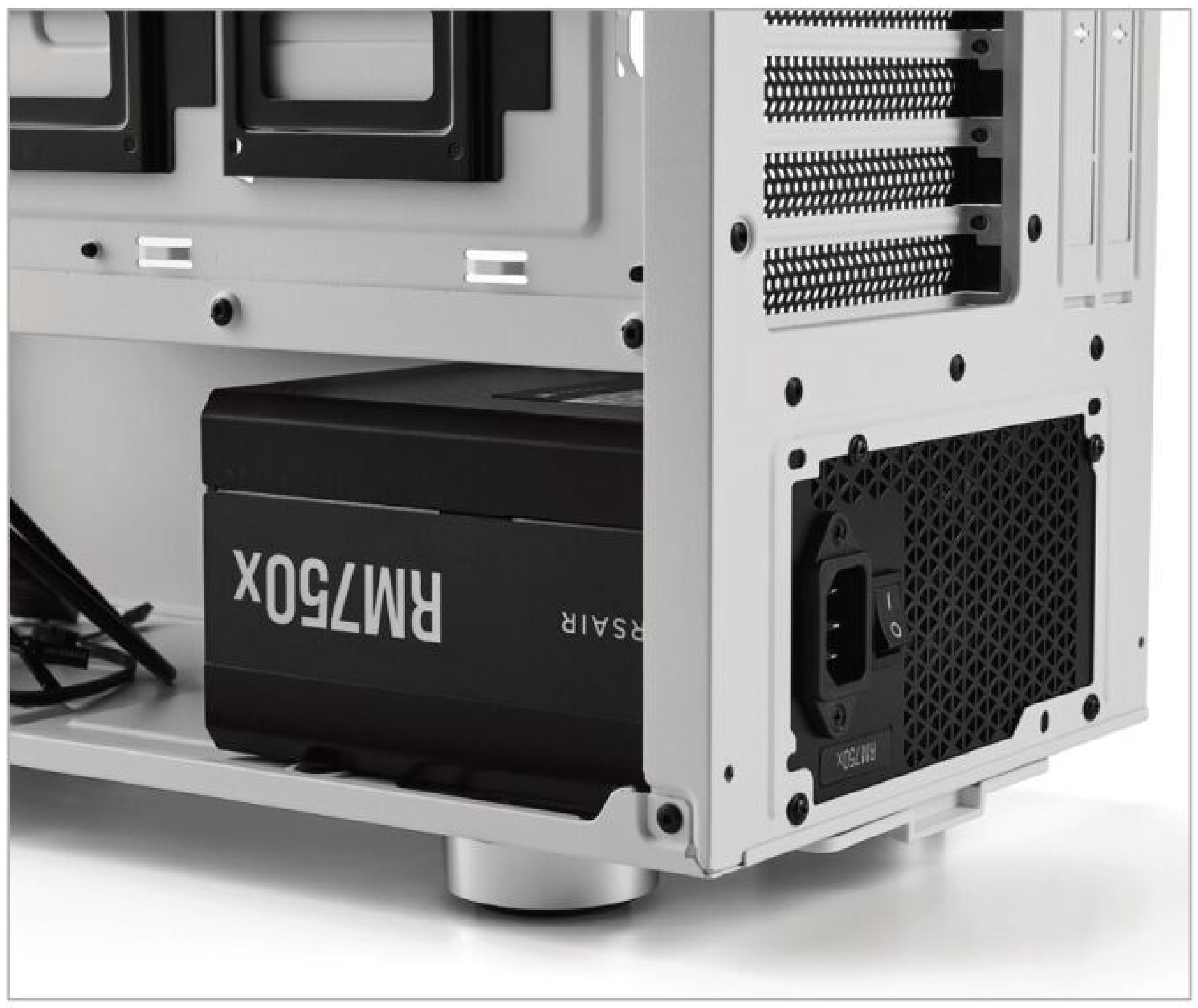
2 ADDING THE LUNGS

BEFORE WE GO any further, we put in the stock fans. We will always need an exhaust fan, so we added this first. With one of the three stock fans we have on offer, we secured this onto the case, with the face of the fan looking inward. This will pull the warm air from the machine away and out the back. For the other two, we screwed them onto the front of the case using the top two spaces, facing the same direction as the exhaust fan. The fans here will bring cooler air in from outside, creating a nice stream of air that flows through our rig. With all of these fans, we made sure that the cables came out towards the back of the case, ready for routing.



3 SUPPLYING THE POWER

WE DON'T OFTEN add the PSU in at this stage, but we threw out the rule book for this month's build. We're not normally that impulsive but on this occasion, we just thought why not? It also adds a nice amount of weight to the bottom of the machine to keep things sturdy. To fit this in, it takes a few small case screws. You can get away with a couple but we always suggest using as many as possible, that's four in our build. Annoyingly the RM750 logo is upside down, but on the flip side, this will be covered by the back panel.



4 CHIP IN

NOW THE POWER SUPPLY is in, we can focus on the motherboard and its components—starting with the most important of all, the CPU. The new 12th-gen chips feature a rectangular design, which makes this step even easier to get the right way round. Before we get there though, we need to lift the retention arm. Unhook the arm by gently pressing down on it and then pulling it to the side to release it. When installing the chip, always align the corner arrow on the chip with the one on the motherboard to ensure the correct orientation. Remember, don't touch the pins when handling the CPU, only the sides. Once this is rested in place, clamp it down by hooking the retention arm back.

5 STORING THE STORAGE

USING THE top M.2 slot, we need to add our sleek SSD onto our motherboard. Our mobo comes with a heatsink shield, so we need to take this off using a screwdriver. Once off, slot the SSD's connecting end into the board at a 30° degree angle and then lower it down onto the screw mount. This should line up with the cutout on the SSD and a plastic slider will secure this into place. Next, grab the heatsink shield and peel off the protective layer. Stick this back onto the board and over the SSD, tightening up the screw in the process.

8 RAM INSTALL

ALTHOUGH MOUNTING our CPU cooler vertically gave us enough clearance to use all four DIMM slots, we only need to use two of those. On most motherboards when you have a memory kit with only two sticks, like our 2x 8GB kit, you only need to use slots two and four. Be sure to always refer back to the motherboard manual to double-check though, as incorrectly slotted RAM can cause the machine to post. To install, release the clips on the necessary slots, line up the notch on the RAM sticks with the board, and push into place. You'll hear a click when you have successfully slotted it in.

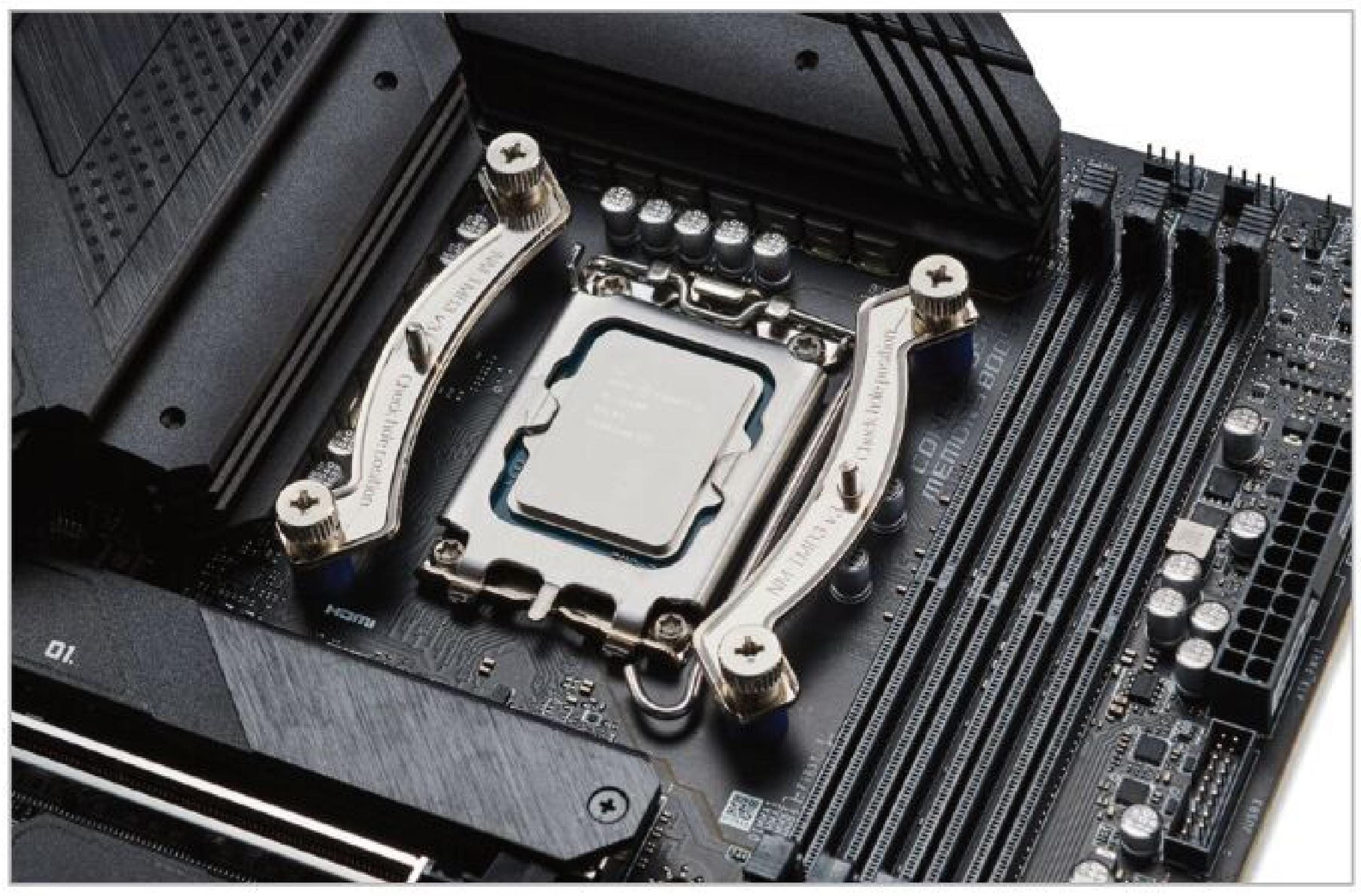
9 IN GOES THE BOARD

WITH ALL BUT ONE of the motherboard components installed, it's time to get the motherboard into the case. Lay the case flat then place the mobo into it by aligning the I/O shield with the slot in the case. Once done, the screw holes on the board should align with the case, tighten it with the case screws. Use as many screws as possible and, ideally, in all corners to get even pressure across the board. Using a long-neck screwdriver will help here, as it can get fiddly in the corners. Dropping a screw into the case is almost inevitable, and there's no denying how frustrating that is.

6 COOLING BRACKET

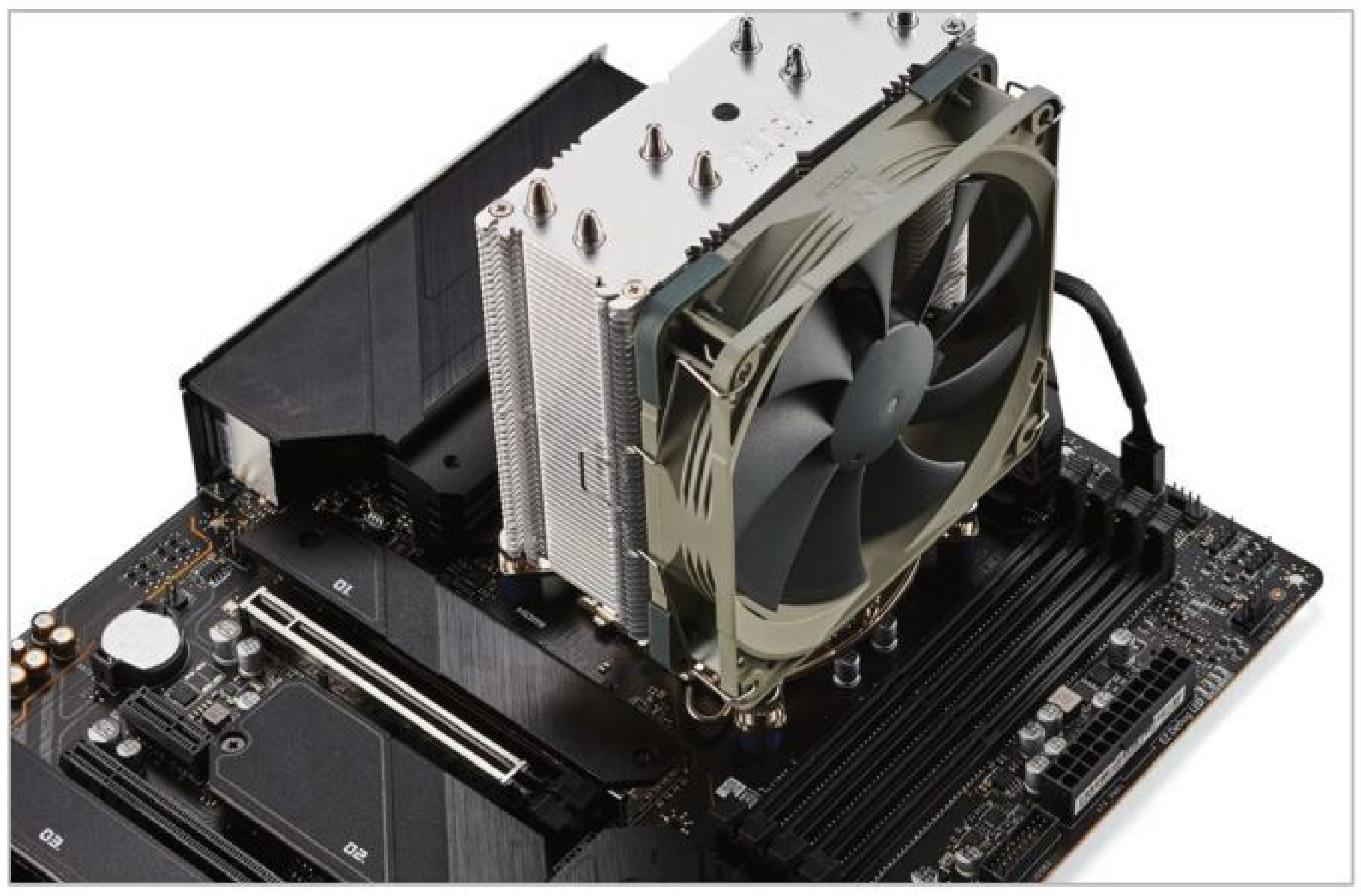
AHEAD OF INSTALLING our Noctua NH-U12S redux, we need to put the bracket onto the back of the motherboard. Using the correct LGA1700 backplate out of the box, slot this on the back of the motherboard. On the pins from the backplate, add the correct spacers for the socket—the blue ones were the ones we needed on our build. Then add the brackets. You have the choice between mounting vertically or horizontally, but to ensure there was enough clearance for our RAM, we chose to mount it vertically.

In the manual, there are three slots that the pins from the backplate can slot into, ours was the middle slot. To finish securing the bracket, we tightened up the thumbscrews onto the pins and now we can add the rest of the cooler.



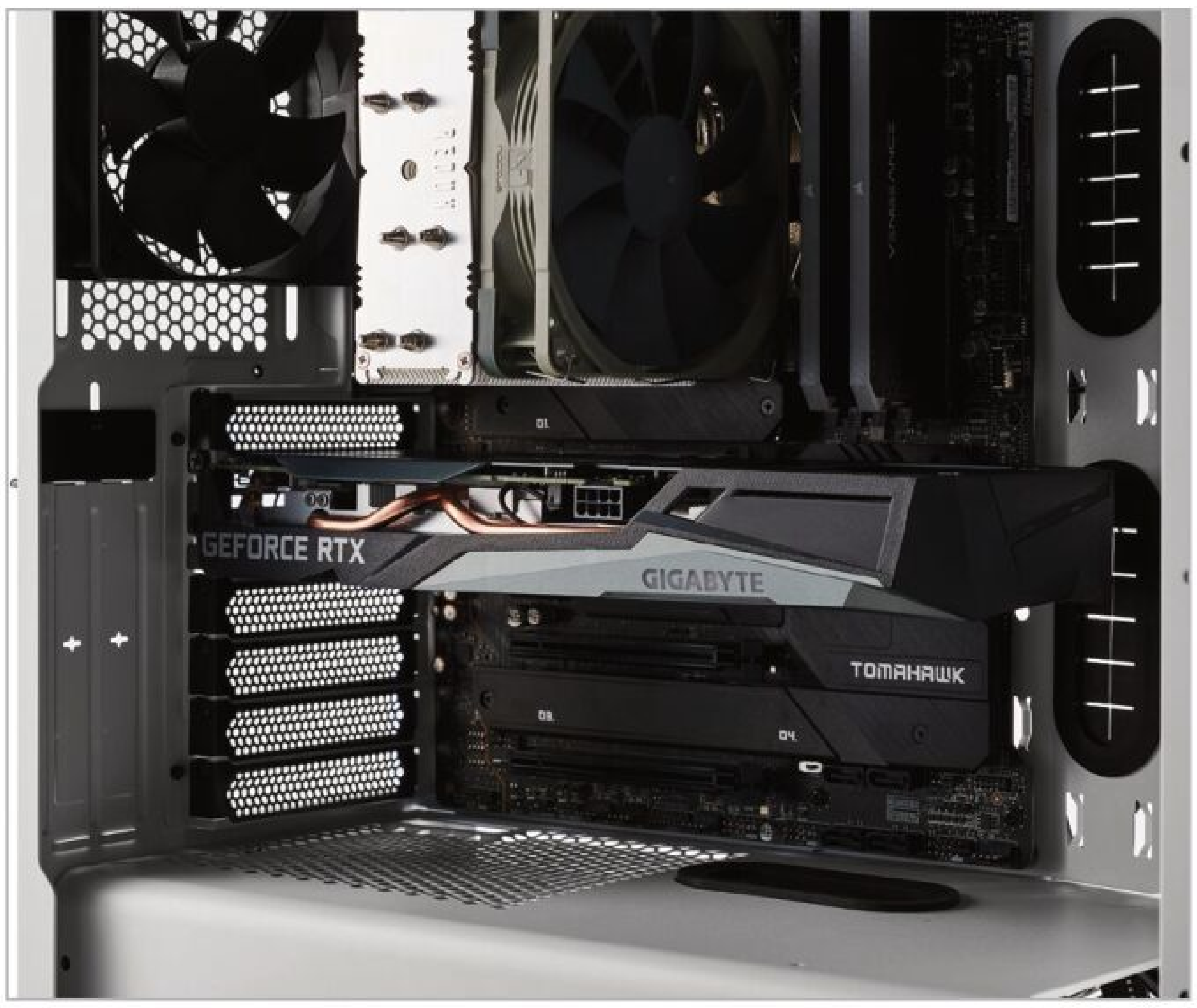
7 CPU COOLER

THANKFULLY, our cooler had pre-applied thermal paste, which even came in a nice hexagonal shape and made the process a lot easier and tidier than if we had applied it ourselves. To attach this to the CPU, we took off the fan by unhooking the clips. This revealed both the screws that align with the CPU bracket, so we gently dropped it down into place and tightened it with a screwdriver. After this is mounted, we attached the fan back onto the cooler block. To maintain the same airflow with the rest of the build, we kept this fan facing in the same direction as the others. We also made sure that the cable came out of the back and attached it to the CPU fan header on the motherboard. There was some excess cable, so we looped this out of the way.



10 THE JUICY PART

YES, THAT'S RIGHT, it's time to add the GPU—there's always something so satisfying about hearing this component click into place. To make room, remove the PCIe cover slots on the back of the case that are aligned with the PCIe slot you are using. It's always best to use the uppermost slot on the board possible. Like the RAM slots, release the clip on the slot, align the notch on the GPU with the one on the board and click it down into place. Then use some case screws to tighten the mount onto the case.



11 CASE CABLES

SO ALL OUR COMPONENTS are now in, but it's no good if nothing is connected, obviously. Before we bring the PSU cables into the mix, we need to connect the case cables and fan cables onto the board. Again, if you are unsure about where to connect the cables, referring back to the motherboard manual could save you a lot of time and energy. Thankfully most headers on the board are named which helps too. When connecting, try to pick the tidiest path to route the cables through and be careful not to bend the pins on the board as they are particularly fragile.

EZ Debug LED

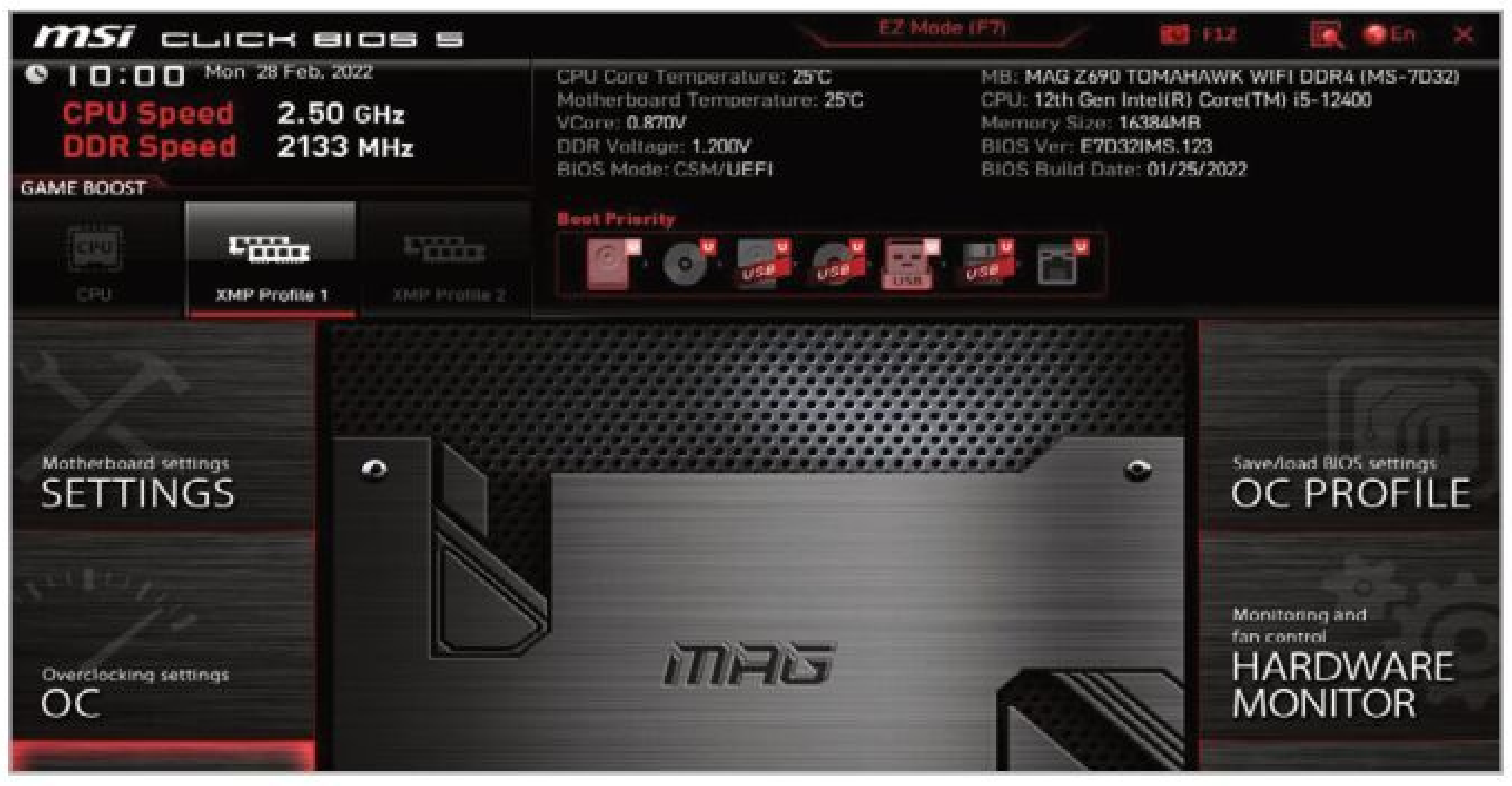
12 PSU CABLES

FINALLY, all we need to do is connect the power cables up and we will have a running machine. These aren't always the easiest to connect as they are tough to bend. Thankfully, this case has great routing options. One of the toughest to get into position is the 24-pin motherboard cable, but with a slot right next to it and just a little force, we could tuck this away through the route. We grouped all of the cables in a bunch and cable-tied them together around the back of the case—that's more for our own peace of mind really, as you wouldn't be able to see it. We then popped all the panels back on, hooked up the power cable to the wall socket, booted it up, and let out a sigh of relief. However, hardware is only half of the story and we need to turn our attention to software.

13 UPDATE THE BIOS

TO MAKE SURE the PC boots, you will more than likely need to update the BIOS. Regardless of whether it boots, it's a step you should do to ensure that your PC runs smoothly as best as it can. To find the BIOS update, use another PC to head over to your motherboard's support page, then download and extract the latest version onto a clean USB flash drive. Make sure the USB you are using has been formatted correctly to FAT32. Then insert this into your new build.

To get to the BIOS, boot up your PC and mash the 'delete' key until it pops up. Once open, choose the M-Flash button, launch it, and select the USB stick. Find your file, click and select yes to all the pop-ups. The BIOS will start to update, so give it some peace and quiet—whatever you do, don't unplug it during the process. When it reboots, you can restart the machine, mash the 'delete' key again, and check the BIOS version to make sure it has updated successfully.



10:00 Mon 28 Feb. 2022
CPU Speed 2.50 GHz
DDR Speed 2133 MHz
CPU Core Temperature: 25°C
Motherboard Temperature: 25°C
VCore: 0.870V
DDR Voltage: 1.200V
BIOS Mode: CSM/UEFI
MB: MAG Z690 TOMAHAWK WIFI DDR4 (MS-7D32)
CPU: 12th Gen Intel(R) Core(TM) i5-12400
Memory Size: 16384MB
BIOS Ver: E7D32IMS.123
BIOS Build Date: 01/25/2022

1080p GAMING, YAY OR NAY?

IT'S ALWAYS A NICE FEELING to make it to the end of a build. This one went pretty smoothly—there were no compatibility issues with our i5-12400 processor and the Noctua cooler, as we had feared. Visually, the Corsair 275R Airflow is a striking chassis and, though we were a little worried about how the cooler would look, the RGB from our Corsair RAM reflects well against the grey fan on the block. The chrome from this matches well with the feet on the machine too.

So it ticks the boxes for aesthetics, but does this machine achieve solid 1080p gaming? In short, yes it does. With a balanced range of components, this rig performed smoothly and was at its strongest in our read and write tests. We benchmarked it against a similarly priced gaming laptop, the MSI Katana GF66. This laptop performed well on its 1080p gaming tests with the sliders cranked to the right, so we wanted to see how our new machine fared against it.

Although it trumped the MSI in the read/write speeds as well as the Cinebench R15 test, thanks to our CPU and SSD combination, the MSI pipped it when it came to gaming. That's not to say that we were disappointed with our results.

On the maximum settings, we saw a performance of around 60fps, ensuring this rig will offer a reliable 1080p experience—sacrificing a few graphical options will bump those figures up. There were other key differences between our PC and the MSI laptop. Our system maintained a consistent low temperature with quiet fan speeds, which can't be said for the laptop. The case and the Noctua U12S redux take the credit.

On the whole, we achieved what we set out to do by building a 12th-generation 1080p gaming rig. Although we can't upgrade to DDR5 on this machine, a good kit of DDR4 will still last the distance and we could always upgrade in time. The RTX 3050 in this rig is a great match alongside the i5-12400 CPU. For around $200, this is ideal if you are making the switch to the 12th generation without breaking the bank.

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi-Thread (Index)	1,352	1,778 (32%)
CrystalDisk Q32 Sequential Read (MB/s)	1,982	3,557 (79%)
CrystalDisk Q32 Sequential Write (MB/s)	1,348	2,779 (106%)
Tom Clancy's Ghost Recon: Wildlands (fps)	89	57 (-36%)
Total War: Warhammer II (fps)	82	72 (-12%)
Rise of the Tomb Raider (fps)	118	113 (-4%)
3DMark: Fire Strike (Index)	16,696	14,995 (-10%)

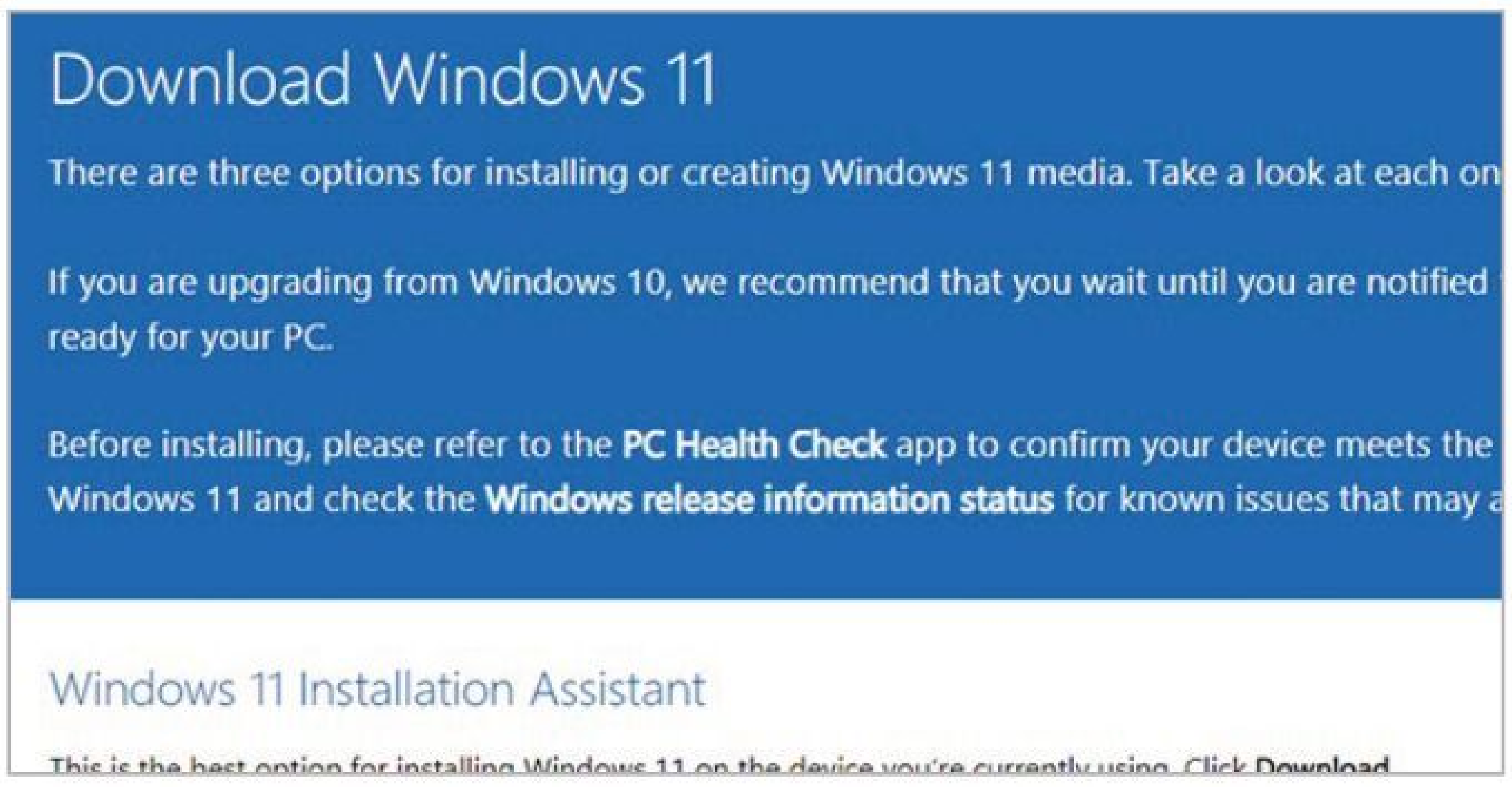
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point is the MSI Katana GF66 laptop, with an Intel Core i7-11800H, Nvidia GeForce RTX 3060 GDDR6 6GB, 16GB DDR4 @3200 and a 512GB SSD. All game tests are performed at 1080p at the highest graphical profile.

© MSI, MICROSOFT, NINITE

14 OS INSTALL

A PC WITH no operating system is like a car without an engine. To install we need to use the Windows Media Creation Tool so, using another PC, search for this on a browser. Again, you'll need a clean USB drive formatted to FAT32 with at least 8GB of storage. Click the link on the browser that takes you to the official Microsoft site then download the 'Create Windows 11 Installation Media' option. Once this has been downloaded, run through the setup wizard and, when it asks you to choose an option of media, select your USB drive. After this has been installed on your drive, plug it into your new PC. You'll need to re-open the BIOS, so spam the 'delete' key again when booting up the new build. Once there, reorder the boot to make the USB drive the priority. Then save this and restart the PC and it should open up the Windows 11 installation process. Now's it's almost time to start to get excited about all the games you're about to install.



Download Windows 11

There are three options for installing or creating Windows 11 media. Take a look at each on

If you are upgrading from Windows 10, we recommend that you wait until you are notified ready for your PC.

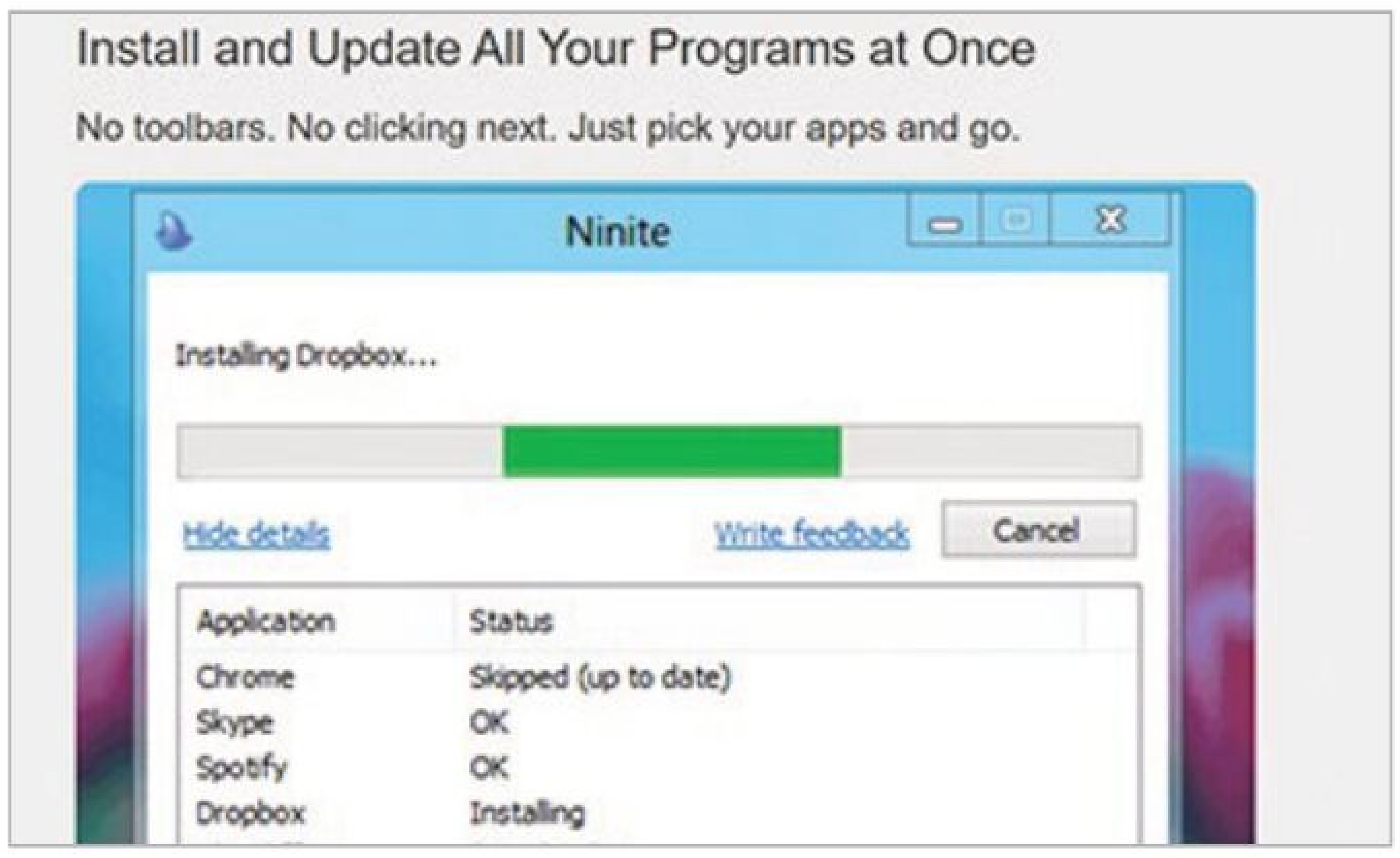
Before installing, please refer to the **PC Health Check** app to confirm your device meets the Windows 11 and check the **Windows release information status** for known issues that may a

Windows 11 Installation Assistant

This is the best option for installing Windows 11 on the device you're currently using. Click **Download**

15 SOFTWARE INSTALL

INSTEAD OF HEADING to a million and one separate websites to get all the browsers, security applications, media programs, utilities, documents, image editing programs, and others you need to get your PC up and running, head over to the Ninite website at www.ninite.com instead. This one-stop-shop will have all the necessary starting applications you will need. Check the programs that you want to install and hit the big download button at the bottom, Ninite will download the most up-to-date apps you will need, it's as easy as that. To ensure your PC is fully optimized, another important step is to download the latest drivers from your motherboard support page and also the latest Intel drivers. Once that's done, you can finally start to enjoy your new build and make the most of it in all its glory.



Install and Update All Your Programs at Once

No toolbars. No clicking next. Just pick your apps and go.

Installing Dropbox...

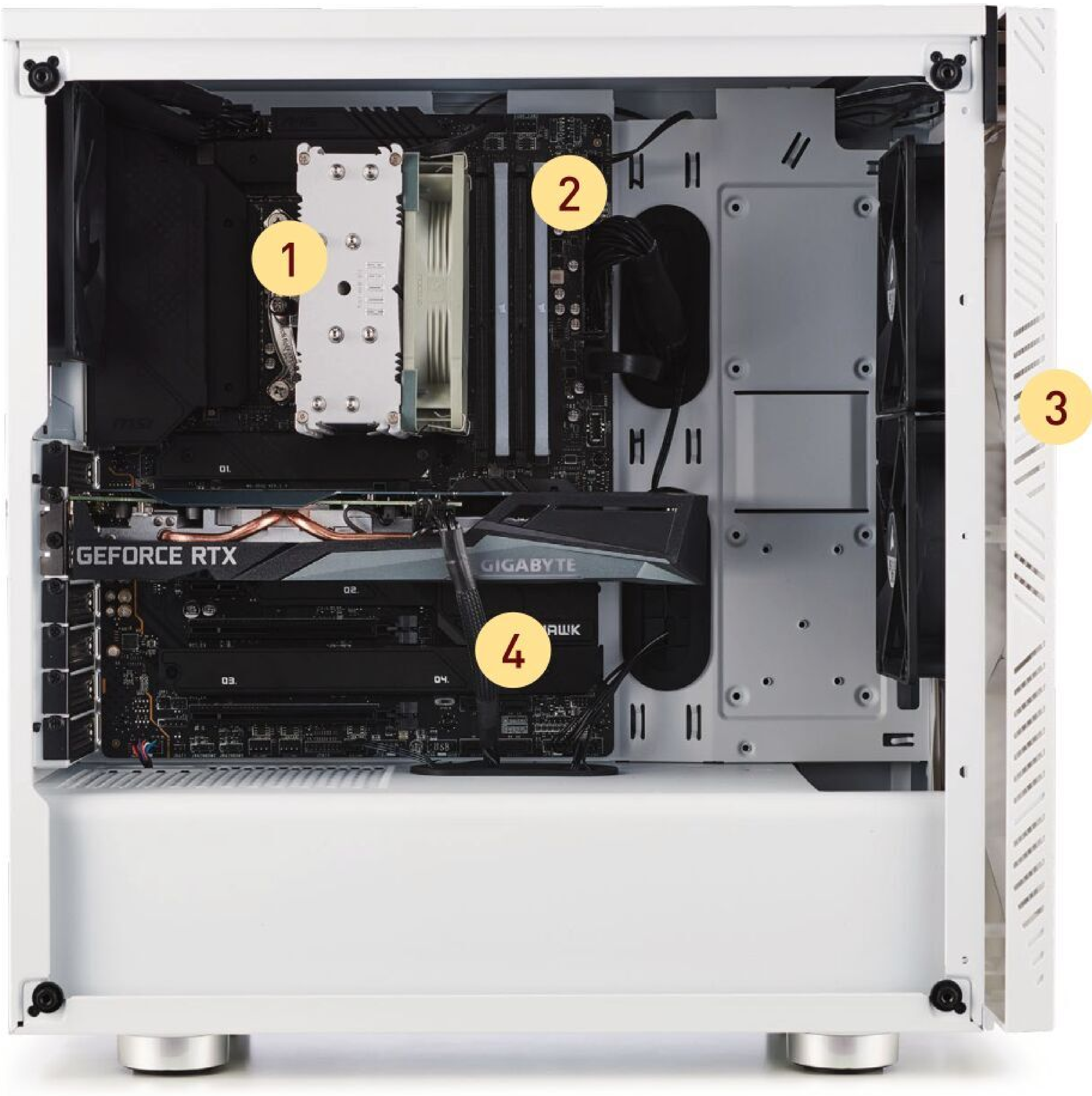
Application	Status
Chrome	Skipped (up to date)
Skype	OK
Spotify	OK
Dropbox	Installing

1 The chrome from our cooler matches the aesthetic of the case well but if we could do it all over again, there is one thing we would change. Adding a matching fan to the other side would not only improve cooling further but would also create a lovely bit of symmetry.

2 A full four-piece kit of RAM would help brighten up the inside of this case and would only further improve performance, so it'd be a win-win situation.

3 We haven't always been big fans of too much RGB but, ironically, in this case, some RGB fans would have helped the aesthetics inside. The light shining through the front grill would have looked impressive.

4 Custom white cables are always going to look better than stock ones. It's a shame we couldn't stretch the budget a bit for this rig, but them's the rules!



RISE OF THE CHROMEBOOK

Are Chromebooks the revolution the laptop space needs or will Windows emerge triumphant? *Christian Guyton* explores

CHROMEBOOKS—plucky little brother to the Windows laptop, typically trading performance for portability and ease of use. An affordable option for performing basic tasks such as word processing and web browsing. While Chromebooks may be disparaged by tech-heads, they've come a long way since their introduction in 2011. Google describes today's ChromeOS laptops as 'speedy, simple and secure', with virus protection built-in and effective cloud-based storage for files and user data. So, how do modern Chromebooks compare to their Windows counterparts? We break down some of the best ChromeOS systems on the market right now—it's about more than just performance, of course; value, ease of use, portability, and general hardware quality will all be factors. Will Chromebooks emerge victorious or should we stick to what we know best?

SPECIFICATIONS

OS	ChromeOS
Processor	Intel Core i3-1110G4
Graphics	Intel UHD Graphics
RAM	8GB LPDDR4X
Storage	256GB PCIe NVMe M.2 SSD
Display	14.0-inch 1080p LCD touchscreen
Connectivity	1x USB 3.2 Gen 1 Type-A, 2x Thunderbolt 4, 1x 3.5mm combo audio jack, Micro SD card reader
Battery	48WHrs 3-cell Li-ion
Size	12.6 x 8.1 x 0.6-inches
Weight	3.09lbs

Asus Chromebook Flip CX5

DESPITE BEING A relatively high-end model, the Asus Chromebook Flip CX5's $700 price tag puts it closer to the budget space, adrift in a market dominated by slick MacBooks and $1,000+ gaming laptops. The Flip CX5 needs to justify its price tag since it occupies that space between more powerful Windows laptops and more affordable Chromebooks.

Out of the box, it's off to a strong start. While Chromebooks have been price-sensitive machines, a design ethos that all too frequently extends to the build quality of the external casing, the Flip CX5 feels premium. It's the heaviest of the three Chromebooks on test here and the largest too. The blue-tinted exterior looks great, with shiny metal hinges that feel remarkably sturdy.

That's a good thing given that this is a 2-in-1, with a gorgeous 14-inch touchscreen. The display is easily the brightest and most colorful of these Chromebooks and feels good to use in tablet mode. ChromeOS lends itself better to the hybrid laptop design than Windows 10 or 11, automatically switching from the conventional desktop mode to a smartphone-esque grid of apps when you convert it into the tablet configuration.

The 16:9 widescreen aspect ratio isn't ideal for productivity, but that's a matter of personal preference. We were a little concerned about the screen and matte casing picking up fingerprints, but it wasn't anywhere near as much of an issue as we had expected. If you're particularly smudge-phobic, there's a slot for an integrated stylus on the right-hand edge of the chassis. This isn't anything special and can be swapped out for any compatible smart pen if you prefer more control.

The keyboard is decent, broadly comparable to any laptop keyboard in the same price bracket, with bright white backlighting and a good amount of travel for a tactile typing sensation. The trackpad is where the whole setup falls down; it feels flimsy, with too much surface friction and an unsatisfying click. It can be converted into an LED-illuminated numpad at the press of a button, though, so we'd recommend leaving it in that mode and using a wireless mouse (or the touchscreen itself).

In terms of performance, the Flip CX5 dominates the other Chromebooks thanks to its 11th-gen Intel Core i3 processor, offering solid performance in both single-core and multi-core workloads. There's a table with benchmark results at the end of this article, but with few tests that can be effectively run on both Windows and ChromeOS, we've used the multi-platform benchmark Geekbench 5 along with 'Aquarium', a WebGL test that renders up to 30,000 animated fish.

Although it doesn't have Intel's shiny new Iris Xe integrated graphics, the i3-1110G4 CPU performs well in the WebGL test, outstripping the Lenovo 500e and Acer Spin 513 Chromebooks and placing itself among the Windows laptops we were testing. With a bit of Linux meddling, we were able to get a few Steam games running on the Flip CX5, albeit non-graphically-demanding ones.

The speakers on the Flip CX5 are underwhelming, and though we'd advise using a headset anyway, the audio was tinny and not especially loud. The battery is a bigger issue; Asus suggests 'up to 10 hours' of battery life, but testing at 50 percent brightness barely gave us six hours of continuous use.

Overall, the Flip CX5 is the best of the three Chromebooks we've looked at here—but it's also the most expensive. We're not convinced it does enough to justify its price tag, especially since better performance is available in Windows laptops at the same cost. Despite that, it's a well-designed product that effectively demonstrates the best of what Chromebooks can be.

VERDICT

8

Asus Chromebook Flip CX5400FM

➕ **BACKFLIP** Stylish physical design; good CPU performance; great screen.

➖ **TUMBLE** Trackpad is poor; battery life could be better; expensive for a Chromebook.

$700, asus.com

SPECIFICATIONS

OS	ChromeOS
Processor	Intel Celeron N4120 Processor
Graphics	Intel UHD Graphics 600
RAM	8GB LPDDR4-2400
Storage	64GB eMMC 5.1
Display	11.6in 768p LED IPS touch screen
Connectivity	2x USB 3.0 Type-A, 2x USB 3.2 Gen 1 Type-C, 1x 3.5mm combo audio jack, Micro SD card reader
Battery	42WHrs 3-cell Li-ion
Size	11.4 x 8.0 x 0.8-inches
Weight	2.89lbs

Lenovo 500e Chromebook

IF YOU'RE reading this magazine, there's a good chance the Lenovo 500e isn't really for you. If you've got kids in your life though, keep reading, because this Chromebook encapsulates the focus on education Google had when creating ChromeOS. Plenty of Chromebooks are aimed at schoolchildren, so it would have been remiss of us not to include one in our breakdown.

The 500e (2nd generation) is, if we're being honest, a bit ugly. The exterior is rubberized plastic with a grippy textured finish, which looks bad but is ultimately designed for small hands and a laissez-faire attitude to hardware safety. It feels durable; you could throw this Chromebook into a locker or backpack without having to worry about protection. The 360-degree hinge feels similarly robust.

Unlike every other device featured in this article, the 500e doesn't have an FHD display. Instead, the small, 11.6-inch display operates just above 720p, at a resolution of 1366x768. The dark screen bezel is excessively chunky, in our opinion, and while color reproduction and brightness are okay, this display is definitely nothing to write home about.

In terms of internal components, the 500e isn't particularly exciting. We've got an Intel Celeron processor, a sensible 8GB of RAM, and a reasonably powerful battery that provides decent longevity given the smaller display; continuous video playback at 50 percent brightness saw the battery give out just shy of ten hours from a full charge. The Celeron CPU isn't going to win any races, but ChromeOS is well-optimized for lower-end hardware so we didn't see any noticeable lagging in everyday use.

One area where the 500e falls down is the drive; it's an eMMC drive with just 64GB of storage space, the same as the Acer Chromebook Spin 513. This being a Chromebook, you're expected to use cloud-based storage, but for anyone who wants to store files locally, it's not likely to be sufficient. An even cheaper version of the 500e exists, with the same CPU but only 4GB of memory and a measly 32GB of storage. Both versions come with an integrated stylus, which feels comfortable to hold in the hand; ideal for taking quick notes in class.

Benchmark performance isn't impressive, but that's hardly surprising given the low-powered processor. Graphical performance is by far the weakest of the devices on test here, with WebGL Aquarium looking a bit like a slideshow. Simple app games from the Android Play Store (now supported on most Chromebooks) will run fine but don't expect much more.

Of course, we've got all the performance needed for this Chromebook's intended purpose. Sixth-grade science homework will be no trouble for the Celeron, with simple tasks (like web browsing and word processing) being just fine. It's perfectly capable of a bit of YouTube or Netflix too, although the tiny screen and lackluster speakers make it a poor alternative to a TV.

Unusually for a laptop, the 500e has two separate cameras. The main 720p webcam is situated at the top of the screen, where one would expect to find it, while a second 5MP camera nestles above the keyboard. This allows the user to take photos or video while using the 500e in tablet mode, functioning as a 'rear' camera. Yes, you'll look like this writer's dad attempting to take holiday photos with his new iPad in 2010, but it works.

Ultimately, the Lenovo 500e does a good job of fulfilling its purpose as a basic, easy-to-use laptop for pre-college students. It's unlikely to appeal to adults (or even older teens) but it functions just fine and has the durability to survive the rigors of being used by a child. No, it isn't exciting, sleek, or powerful, but it's fit for the task it was designed for.

VERDICT
7

Lenovo 500e Chromebook 2nd Gen

+ **MODEL STUDENT** Good battery life; rugged design; affordable.

− **PROBLEM CHILD** Limited local storage; looks bland; rubbish screen.

$400, lenovo.com

FULL HD 1080
acer

SPECIFICATIONS

OS	ChromeOS
Processor	Qualcomm Snapdragon 7c
Graphics	Qualcomm Adreno 618
RAM	4GB LPDDR4X
Storage	64GB eMMC 5.1
Display	13.3-inch 1080p LCD touchscreen
Connectivity	1x USB 3.2 Gen 1 Type-A, 2x USB 3.2 Gen 2 Type-C, 1x 3.5mm combo audio jack
Battery	42WHrs 2-cell Li-ion
Size	12.2 x 8.2 x 0.6-inches
Weight	2.84lbs

Acer Chromebook Spin 513

THOUGH THE Acer Spin 513 sticks to the Chromebook script, with its touchscreen, hybrid tablet design, and underpowered speakers all par for the course, where the Spin 513 differs is its processor; rather than an Intel chip, this Chromebook uses a Qualcomm CPU.

The Spin 513 is powered by Qualcomm's new Snapdragon 7c processor, an octa-core CPU that promises to deliver industry-standard performance with Adreno integrated graphics while improving battery life and reducing heat generation.

It's an ARM-based chip, and ChromeOS is well-optimized for ARM, as are the Android apps available through the Play Store on every Chromebook. However, users who want greater flexibility to run virtual Linux environments are likely to run into compatibility troubles with some Linux apps.

In terms of overall specs, the Spin 513 isn't immediately impressive. A modest 4GB of RAM is joined by a dinky 64GH eMMC drive, the latter presenting the same problems for local storage as the Lenovo 500e. The battery is a 2-cell lithium-ion affair; one less cell than those seen in the other Chromebooks on test here, though that shouldn't be an issue, given the Snapdragon processor's lower power draw.

Those figures make sense when you consider that the Spin 513 costs just $20 more than the 500e. Other areas are more impressive than Lenovo's child-friendly Chromebook, with a 13.3-inch 1080p display offering good brightness and color clarity. The screen shows up fingerprints if used heavily in tablet mode, though.

Build quality is also solid, while still managing to look good. It hasn't reinvented the way laptops look, but its matte silver exterior and small screen bezel mean it looks just as good as pricier Windows notebooks. The hinge feels secure when switching between tablet and laptop modes, and there's little flex to be felt in the plastic casing while typing or using the trackpad.

There's not much to say about the Spin 513's keyboard. As with most thin and light laptops, there's little travel and the keys will feel spongy to anyone used to typing on a mechanical keyboard, but overall it's fine. The trackpad, on the other hand, is the best of the three Chromebooks we tested. A Gorilla Glass coating means it feels both smooth and durable, with a satisfying click to boot.

Performance-wise, the Spin 513 manages what we expected from a Snapdragon processor. The Adreno 618 graphics are perfectly sufficient for app games and general use, and CPU performance is comparable to the Intel Celeron chip found in the Lenovo 500e. Provided you aren't opening too many Chrome tabs at once, you shouldn't see any slowdown. However, the 7c is still far behind any of Intel's Core processors, even lower-end i3s, and the paltry amount of RAM doesn't help considering ChromeOS's memory-guzzling tendencies.

The Snapdragon chip's lower power requirements provide some boons. In the same battery test used for the other Chromebooks, the Spin 513 managed over 13 hours of continuous operation, offering the sort of 'all-day' battery life professional users have been craving. The reduction in excess heat production also means no fan noise, making the 513 the quietest of all the devices in this article.

It has a familiar selection of ports including two USB-Cs (one of which is also used for charging). The MicroSD card reader found on the other two Chromebooks is conspicuous in its absence here, though that will only be a concern for a few potential buyers.

At its price point, the Acer Spin 513 is one of the better Chromebooks available right now, but it's perhaps not the poster boy for ARM-based CPUs that Qualcomm hoped it would be.

VERDICT 7

Acer Chromebook Spin 513 CP513-1H

+ SPINNING
Excellent battery life; amazing trackpad; runs super quiet.

− DIZZY Performance is average; glossy screen; ARM platform is limited compared with Intel.

$420, acer.com

SPECIFICATIONS

OS	Windows 10
Processor	AMD Ryzen 3 4300U
Graphics	AMD Radeon Graphics
RAM	8GB DDR4-3200
Storage	256GB PCIe NVMe M.2 SSD
Display	15.6-inch 1080p IPS touchscreen
Connectivity	2x USB 3.2 Gen 1 Type-A, 1x USB 3.2 Gen 2 Type-C, 1x HDMI, 1x 3.5mm combo audio jack
Battery	41WHrs 3-cell Li-ion
Size	14.2 x 9.2 x 0.7-inches
Weight	3.86lbs

HP Pavilion 15

HP'S PAVILION 15 range is broad, with prices ranging from this sensible $500 model to more powerful iterations with dedicated GPUs that run for around $1000. This version is a reserved affair, with a Ryzen 3 4300U processor, 8GB of DDR4 memory, and 256GB of speedy NVMe storage.

The Pavilion 15's defining feature is right there in the name: a lovely 15.6-inch touch panel, offering excellent brightness and plenty of screen real estate for productivity-focused users. The large display means a bigger overall size, so we've got a full-sized keyboard complete with numpad crammed in here too, as well as a nice wide trackpad that handled better than we'd expect for a $500 laptop.

Despite the size, this is by far the cheapest of the Windows laptops on test here. It's not hard to see where HP has opted to trim the fat to save precious manufacturing dollars; there's no keyboard backlighting, and the chassis is entirely plastic. It's fairly heavy and won't fit as easily in a shoulder bag, but with the lid closed it's almost as thin as the competing laptops—thinner, in fact, than the chunky Lenovo 500e Chromebook.

There's a relatively generous selection of ports to choose from, notably including HDMI, an increasingly rare sight on thin budget laptops. Note that this HDMI out is best used simply for hooking up a larger display for presentations or videos, not for gaming or regular dual-screen use. The Ryzen 3 chip inside this Pavilion 15 goes without discrete graphics, relying instead on its Radeon iGPU.

It's fair to say that high-level gaming and creative workloads aren't really on the table here, although the Radeon Graphics did alright in our hardware-accelerated WebGL test. Day-to-day use with a bit of light indie gaming is not likely to pose any problems. The 4300U handled itself well in the single-core Geekbench 5 test, but multi-core performance was significantly less impressive. Still, for general productivity tasks, this Pavilion 15 shouldn't run into any trouble.

It's also remarkably quiet and cool, perhaps thanks to the lower-spec processor. Our other laptops were a little noisier during benchmarking, while the Pavilion gave barely a fan-whisper. Provided you ensure the vents remain unblocked (that means no using it in bed!) the thermal performance is great.

One might hope that the lower-spec components would mean that this laptop's battery life could stretch for a little longer, but unfortunately that isn't the case. Although the fast-charging function works well, filling to a full charge from empty in under an hour, that big display drains the tank fast and HP evidently had to scale back battery capacity to keep the price down. Continuous video playback at 50 percent brightness saw this Pavilion give up the ghost after just six hours and 20 minutes.

We've certainly seen worse battery longevity (cough, gaming laptops, cough), but we'd really like to see better from a productivity-focused machine. Whatever the large screen says, this isn't meant to be a desktop replacement, so good battery life for a nine-to-five in the office and on the go is essential.

Battery aside, we have to admit that the Pavilion 15 certainly looks like a high-quality product regardless of its lower asking price. It's a big, bold design in striking silver, with matching keycaps and a pleasingly shiny HP logo on the back of the lid.

Although the chassis might be all-plastic in composition, it doesn't feel flimsy. Typing felt good, with the best key travel and little flexing even on firm button presses.

For $500, you could do a lot worse than this Pavilion 15—though we can't help but wonder if the more expensive versions packing Intel's 11th-gen CPUs might be a better shout for most.

VERDICT
7

HP Pavilion 15-eh0007na

+ PAVING **Quiet and cool; nice big screen; reasonably priced.**

− CONCRETE **Weak multi-core performance; poor battery life; somewhat heavy.**

$500, hp.com

SPECIFICATIONS

OS	Windows 10
Processor	AMD Ryzen 7 5700U
Graphics	Nvidia GeForce GTX 1650
RAM	16GB LPDDR4X
Storage	512GB PCIe NVMe M.2 SSD
Display	14in 1080p LCD IPS non-touch
Connectivity	2x USB 3.2 Gen 1 Type-A, 1x USB 3.2 Gen 2 Type-C, 1x HDMI, 1x 3.5mm combo audio jack
Battery	59WHrs 4-cell Li-ion
Size	12.7 x 8.4 x 0.7-inches
Weight	3.31lbs

Acer Swift X

THE ACER SWIFT series of notebooks has been around for a while, but the Swift X is a step forward for the manufacturer. While previous Swift models ran the gamut of budget to premium, the Swift X is looking to be all things to all people—discrete graphics for gaming and creative tasks, a powerful Ryzen 5000 CPU, all-day battery life, and a sleek, lightweight form factor.

In terms of physical design, at least, it holds up to this ethos well. It's certainly not the thinnest nor lightest ultrabook on the market, but it's perfectly portable at 3.33lbs and keeps its screen bezel small despite a decently sized 14-inch display. This LCD IPS panel isn't a touch screen, unlike the other laptops it's up against, but it's a nice screen nonetheless; color reproduction and contrast are excellent, and the matte finish means it functions well in brightly lit environments.

The exterior casing is machined aluminum available in a variety of colors, while inside the lid we've got plastic construction. Opening up the Swift X sees the screen base push the bottom half of the chassis upwards slightly, improving the typing experience by angling the keyboard towards the user. The keyboard is a bit soft, with a mushy feel to the keys and too much flex in the casing on firm key presses. The trackpad is better, with a smooth surface and a robust, responsive click.

All the usual aspects of a modern mid-range notebook are here, from the standard 720p front-facing webcam to a fingerprint scanner for Windows Hello logins. There is the same selection of ports offered by the HP Pavilion 15, too; two USB-As, USB-C, HDMI, and an audio jack.

One unusual design choice is the single-fan cooling system, which vents exhaust heat towards the screen, at the top of the keyboard. During benchmarking, the Swift X felt the warmest of the laptops we tested, although the lone fan meant that it was also quiet even mid-benchmark. Internal temperatures didn't reach concerning levels, but this isn't a laptop you'll want on your lap for long periods.

Our review model of the Swift X is one of the more affordable ones, with a powerful Ryzen 7 5700U processor and a slightly less impressive GeForce GTX 1650 graphics card. These are joined by 16GB of soldered RAM and half a terabyte of high-speed M.2 SSD storage.

It's a capable setup, with a fantastic performance in multi-core workloads and rapid file transfers. WebGL performance wasn't amazing, but the dedicated GPU can handle intermediate-level creative workloads and most games will run fine at 1080p with medium to high graphics settings.

But the three-year-old GTX 1650 is looking a bit dated now; add a couple of hundred bucks onto the price and you can get a Swift X with a newer RTX 3050 or 3050 Ti, which should offer between 15 and 35 percent better performance with little impact on the battery life or thermal management. Yes, this model is cheaper, but we would question the logic behind buying a 1650 model when 3050 versions are in the same ballpark.

Acer suggests that the Swift X can get up to 17 hours of continuous operation, which we're calling bull on (unless you fancy squinting at your idle desktop with minimum brightness all day). Still, our testing saw it survive well past the ten-hour mark, ensuring that you won't run dry during a busy workday.

Ultimately, this is a solid all-rounder laptop for under $1,000. Yes, you could easily get better performance at this price point, but not without sacrificing either its compact nature or its lengthy battery life. The Swift X is an effective tool for both work and play, an excellent choice of laptop for the busy creative or office worker who likes to squeeze in a bit of gaming on the train journey home.

VERDICT
8

Acer Swift X SFX14-41G

+ SPEEDY 5700U CPU is excellent; good display; battery life is solid.

− SLOW GTX 1650 is showing its age; runs hot under load; keyboard isn't great.

$849, acer.com

SPECIFICATIONS

OS	Windows 10
Processor	Intel Core i7-1185G7
Graphics	Intel Iris Xe Graphics
RAM	16GB LPDDR4X-4267
Storage	512GB PCIe NVMe M.2 SSD
Display	13.4-inch 1200p IPS touchscreen
Connectivity	1x USB 3.2 Gen 1 Type-A, 1x USB 3.2 Gen 2 Type-C, 2x Thunderbolt 4, 1x 3.5 combo audio jack
Battery	70WHrs 4-cell Li-ion
Size	11.8 x 8.75 x 0.6in
Weight	2.98lbs

MSI Summit E13 Flip Evo

AT $1,200, this is the most expensive product on this list. It's still decidedly mid-range as laptops go, although you'll struggle to spend that much money on a Chromebook. The Summit E13 Flip Evo works hard to justify its pricing, with some dedication on MSI's part to make it feel like a premium ultrabook with a hybrid tablet design aimed at fast-movers.

MSI is better known for its PC gaming rigs and components in the US, but it has cornered a decent share of the laptop market in Asia and every so often one of its best products makes the leap over. The Flip Evo is an eye-catching product, with a golden trim surrounding the edges of its black, machine-milled metal exterior. It's thin and compact, reminiscent of pricier convertibles such as the Asus Zenbook Flip 14 or the HP Spectre x360.

Despite its diminutive stature and mid-range pricing, the Flip Evo has an exceptional display, using a 16:10 aspect ratio with a 1920x1200 resolution (which MSI calls FHD+, although that's technically 2220x1080). That 'golden ratio' means there's plenty of display space for productivity and web browsing, and it's a reasonably colorful panel with good maximum brightness. It's a touchscreen too, and while the bezel is far from the thinnest we've seen, it's not too chunky. The 16:10 ratio and thick bottom edge mean that the Flip Evo is a bit cumbersome to hold in tablet mode, but this won't be a concern for most users.

Aside from the gorgeous display, one major selling point of the Flip Evo over its rivals here is the inclusion of the MSI Pen, a sleek and lightweight smart stylus that snaps magnetically to the edge of the laptop when not in use. It's ideal for sketching or note-taking and though not as sophisticated as devices such as the Apple Pencil, palm rejection is reliable and sensitivity is good.

The trackpad is on the small side, which might be an issue for some users, but it feels good to use with a soft surface texture and firm click. The keyboard is also decent; more expensive laptops offer better typing experiences, but the keys have a reasonable amount of travel and don't feel too spongy. The keys are backlit in a soft white that wraps around the edges of each keycap, giving the layout a well-defined appearance.

The internals of this laptop don't fail to impress either. We've got a powerful Intel Core i7-1185G7 processor with Iris Xe integrated graphics, backed up by 16GB of speedy memory. Although it doesn't quite match the Ryzen 7 CPU in the Acer Swift X for multi-core performance, it dominates single-core workloads and the Xe graphics are good enough for some light gaming on the Flip Evo's lovely screen. It doesn't get too hot either, thanks to two powerful fans—although during demanding operations they do get a little bit noisy.

The drive is a speedy M.2 SSD with 512GB of storage, which should be more than enough for the average user. There's also an array of physical ports, from standard USB-A to a pair of Thunderbolt 4 ports, which allow for display daisy-chaining, high-speed transfers, and fast-charging. The Flip Evo also has ultra-low-latency WiFi 6E, the first laptop of its kind to feature it.

Battery life is also good, although it falls short of MSI's suggestion of 20-hour productivity. Practical testing saw the battery last for a little over nine hours from a full charge, which is sufficient for a day's work. Other features include a familiar 720p webcam, a fingerprint scanner, and speakers that are good, if lacking in bass.

Ultimately, it's a little pricey given its performance capabilities. But it's difficult to dislike the Summit E13 Flip Evo. It's a genuinely well-designed hybrid laptop free from the bloatware crammed in by OEMs like HP, with a designer aesthetic and good all-round performance.

VERDICT 9

MSI Summit E13 Flip Evo A11MT

+ PEAK Fantastic display; solid keyboard and trackpad; MSI Pen is great; gorgeous design.

− VALLEY Somewhat expensive given its performance; a bit bulky for tablet use.

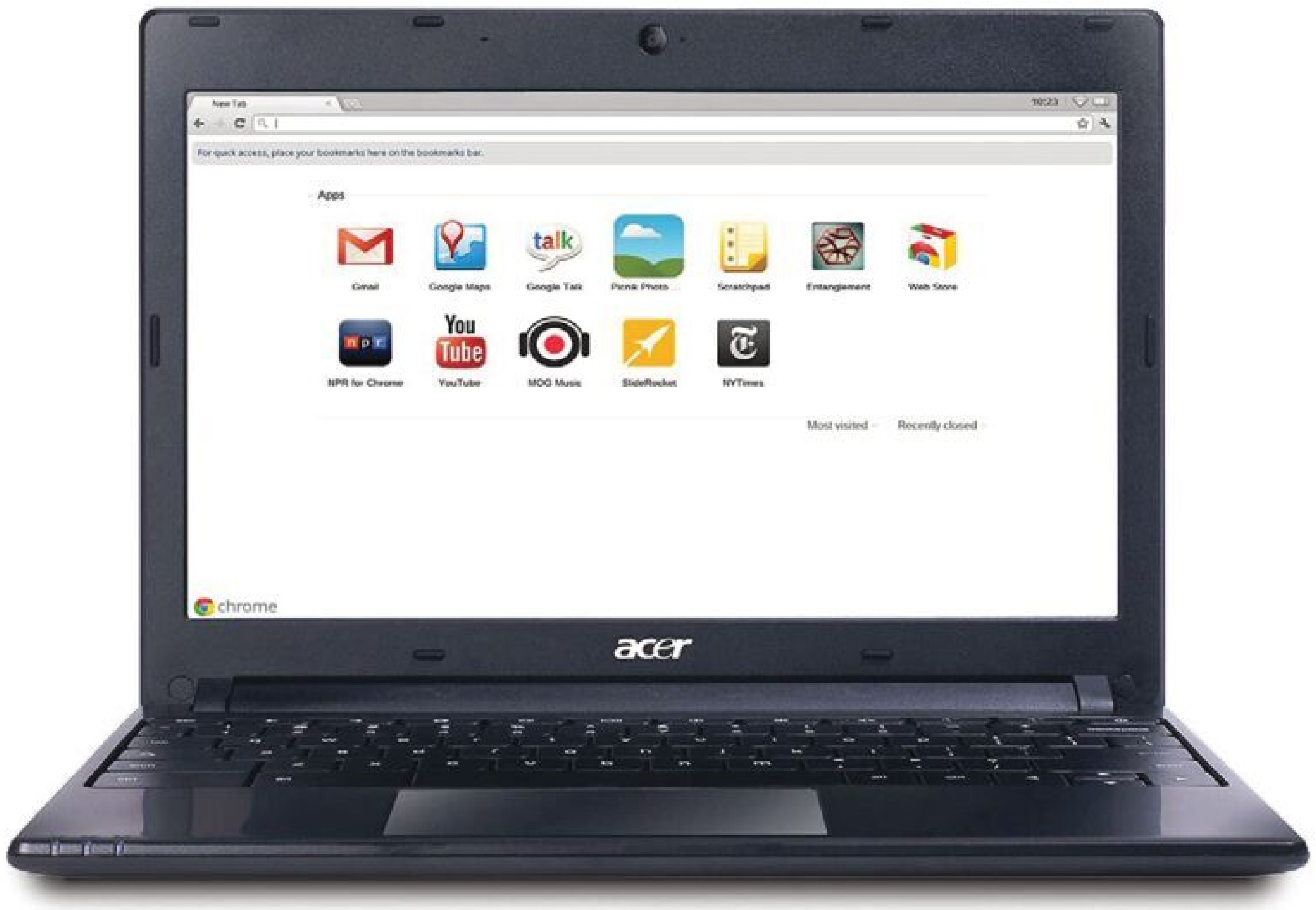
$1,200, msi.com

CONCLUSION

WHAT DID WE LEARN FROM ALL THIS? Well, we won't be making the switch to Chromebooks anytime soon, but then again we aren't the target audience. When you spend your work hours drooling over high-performance hardware, Google's sensibly-priced, security-focused laptops aren't exactly a turn-on. But Chromebook design has come a long way from its origins (check out that Acer AC700, for instance!). Modern Chromebooks can match mid-range laptops for aesthetics; the Asus Chromebook Flip CX5 is the perfect example, combining thin-and-light design requirements with a clean, refined look. While older Chromebooks looked most at home in the IT rooms of elementary schools, cash-strapped university students no longer need to feel ashamed by their hardware if they opt for Chrome.

If you're on a tight budget or looking for 'Baby's First Laptop', Chromebooks just make sense. They won't break any performance records, but ChromeOS is so well-optimized for low-end hardware at this point that these laptops can do a lot with a little, covering all the bases from surfing the net to watching Netflix. Gaming still remains out of reach for most Chromebooks, but that's largely alright considering that PC gaming is still more the domain of over-18s (a 2020 study by the ESA found that children are more likely to play games on a home console, handheld, or smartphone). App games via the Play Store are still an option too, and with mobile gaming booming, those games are genuinely improving in quality. There are still plenty of low-quality, microtransaction-riddled cash-grabs, but indie PC hits such as *Slay the Spire* and *80 Days* mean that fine gaming experiences are definitely not in short supply on ChromeOS.

Beyond the Play Store, we did a bit of software gymnastics to get Steam running on these Chromebooks, just to see what our options were. This can be done in two ways; the first is simple, using Valve's Steam Link app to turn your laptop into a streaming platform. This requires a separate PC from which to stream your games, so you'll need a gaming PC at home for this. Steam Link is a functional (if occasionally buggy) tool, but it pales in comparison to proper game-streaming services such as Google Stadia and Nvidia's GeForce Now.



The Acer AC700 Chromebook won't win any beauty contests.

The other option is more complicated. By using the beta developer tools available in the current version of ChromeOS, you can install a Linux environment on your Chromebook, which allows you to run Steam locally without the need for Steam Link. This uses the Chromebook's own hardware, which has drawbacks. *Stardew Valley* and *Terraria* ran fine, but games with 3D graphics aren't really an option; we tried testing XCOM 2 without much luck. We managed to get *Portal 2* running on the Asus Flip CX5 with a dismal framerate, but it refused to boot at all on the other Chromebooks.

Of course, plenty of games available on Steam aren't set up

AND ALL THE REST

There were plenty of Chromebooks we would have loved to feature in this article but couldn't due to time constraints or hardware availability. The big one was Google's own Pixelbook Go, a premium Chromebook that offers the best of what the platform can do. The Go features a sturdy but thin design, stellar battery life, and one of the best keyboards found on any notebook laptop. Higher-spec models also offer a 1080p webcam and even a 4K touch display.

We'd also point the ChromeOS curious towards Lenovo's IdeaPad Duet, a Chromebook with a detachable keyboard for a true tablet experience. The Duet's hardware specs are modest (4GB of RAM and a MediaTek ARM processor) but given its sub-$300 price tag, we can't be too critical.

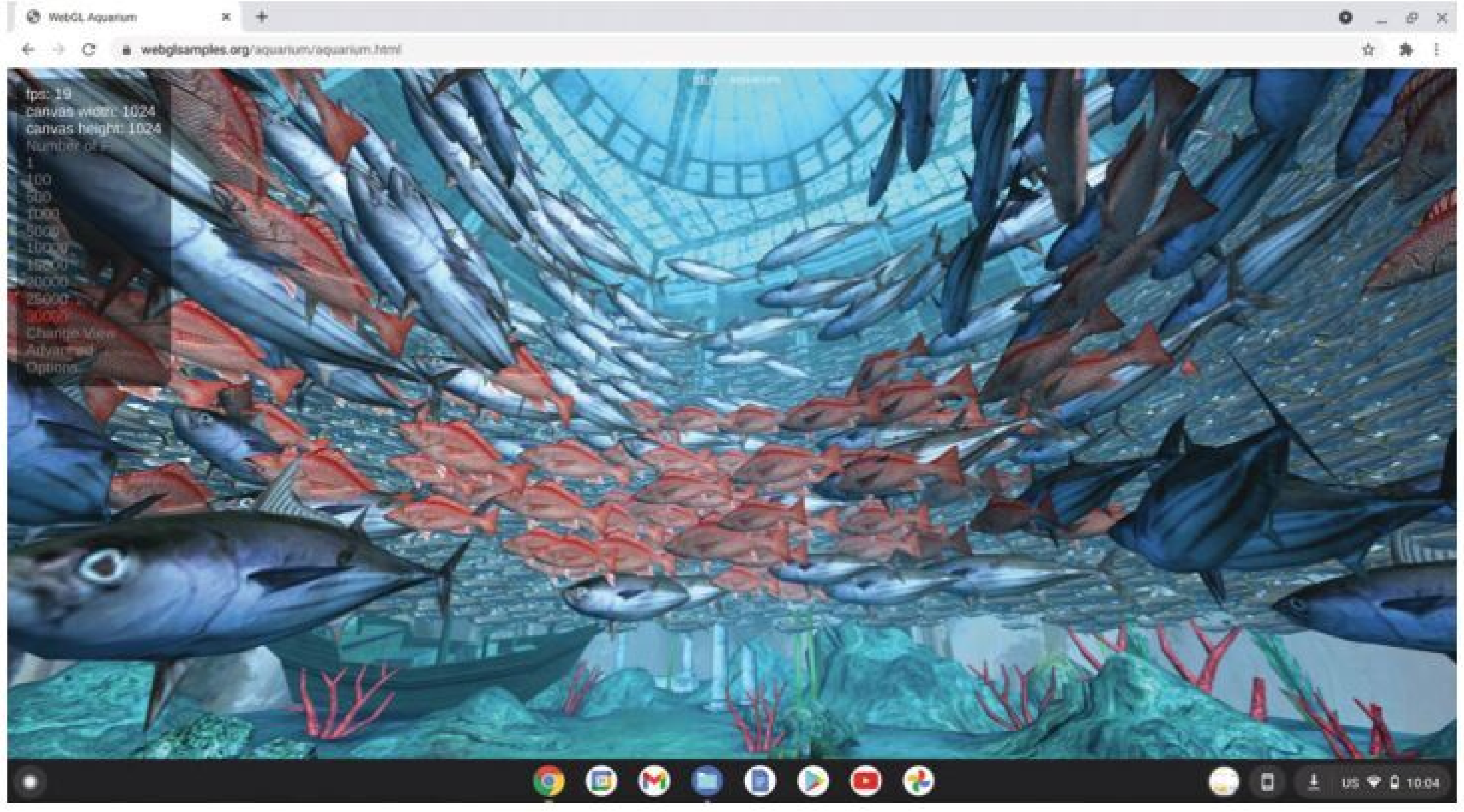
HP's Chromebook x2 11 also uses a detachable keyboard but ramps up the quality with a 1440p touchscreen and fingerprint scanner built into the power button. It's powered by the same new Snapdragon 7c processor from Qualcomm that we saw in the Acer Spin 513, which feels more at home in a tablet than a regular laptop. We should be getting one soon, so keep an eye on our reviews section.

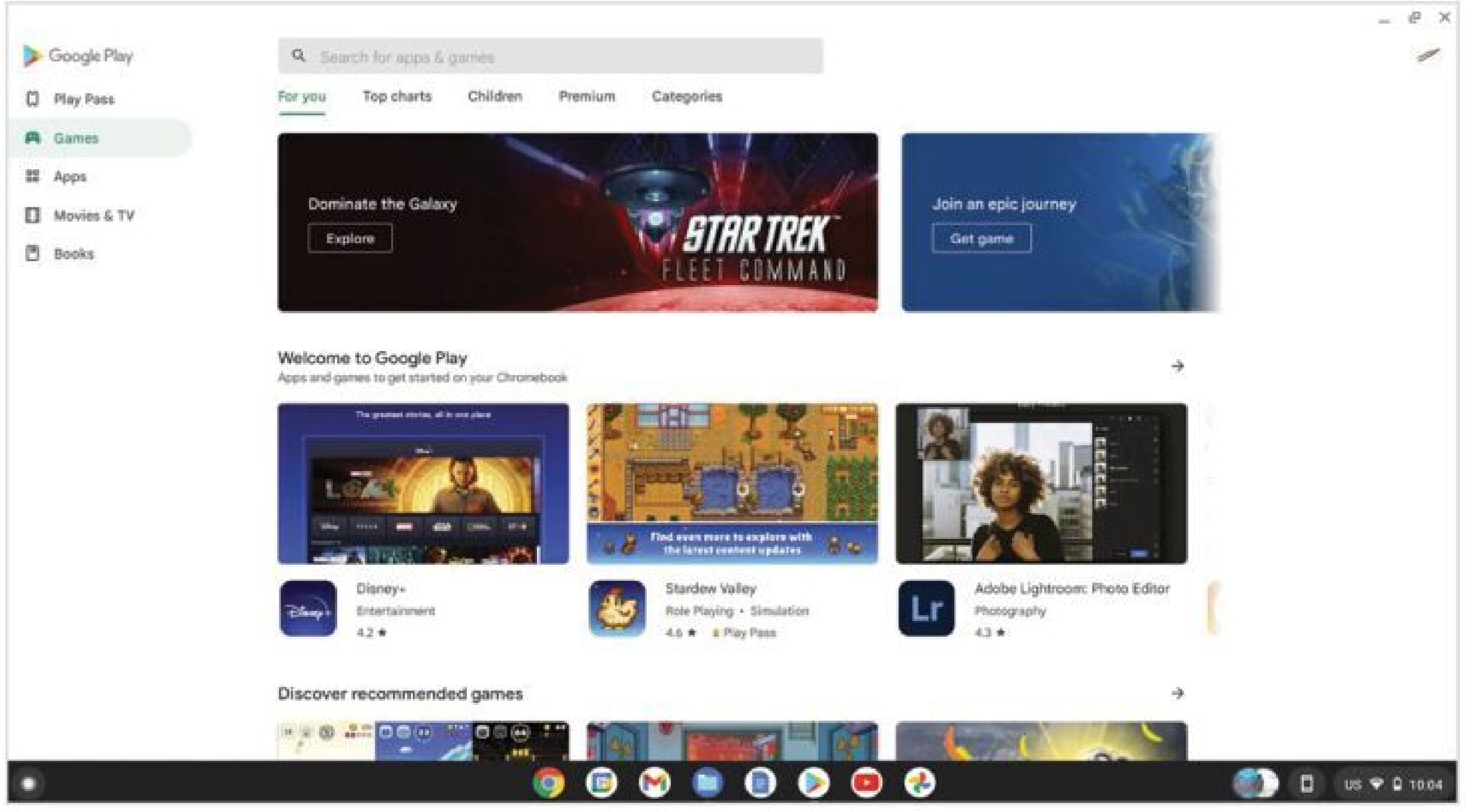
Another affordable option is Acer's 515, which snubs the convertible design of most current Chromebooks for a 180-degree hinge that keeps things simple. No bells and whistles here; no stylus, no IR camera, just reliable performance and a powerful battery for all-day use. Its all-aluminum exterior ensures durability, and it's bundled with a mouse so you don't have to use the basic trackpad. In other words, it's a laptop for people who don't like laptops.

Google's own Pixelbook Go is an Intel-powered Chromebook that showcases the best of what the platform can do.

BENCHMARKS

	Geekbench 5 (single core index)	Geekbench 5 (multi core index)	WebGL Aquarium 30000 (fps)
Asus Chromebook Flip CX5	1,196	4,689	25
Lenovo 500e Chromebook	499	1,591	3
Acer Chromebook Spin 513	533	1,572	9
HP Pavilion 15	992	2,830	25
Acer Swift X	1,183	7,075	20
MSI Summit E13 Flip Evo	1,451	5,379	27


The WebGL-powered Aquarium test is a good way to check the graphical performance of low-powered machines.



Google Play Store offers a range of compatible Android apps and games, though you can also get Steam running on a Chromebook.

for Linux compatibility. Using Steam's own Proton Experimental Steam Play function, you can potentially run Windows titles that won't normally run natively on Linux platforms. However, this only works for a limited number of games, and you'll still be bound by the restraints of your Chromebook's local hardware.

Hardware aside, ChromeOS is a far more powerful operating system than it used to be. Gone are the days of slow internet hamstringing the entire platform, and navigating the menus of the OS is a process that has been streamlined to result in a genuinely pleasant experience. The 'Everything Button' present on every new Chromebook is also a nifty addition, allowing you to search the web and your local device for whatever you need.

With all that said, we still prefer Windows. It's a platform that allows for greater flexibility and customization, with support for the broad range of applications that tech-heads need. While the Windows laptops we featured here were running Windows 10, all are eligible for a free upgrade to Windows 11 and will come preloaded with the newer OS if you buy them new.

The burning question that we're left with is this: where do Chromebooks go next? The inevitable continuation of refining both the OS and the physical hardware is one thing, with Chromebooks swiftly catching up to conventional laptops in appearance, but can we expect to see Chromebooks seize even more of the market share away from Windows? In 2020, Chromebooks overtook MacBooks for the first time in sales volume, largely by eating into Windows laptop sales rather than consuming Apple's market share. Sure, this leap was driven by the pandemic forcing students and office workers into studying and working from home, but sales figures have remained strong and introducing a young generation to the ChromeOS platform is likely to work well for Google in the future.

Indeed, targeting a younger audience and doubling down on its focus on Chromebooks as a tool for education could be the way to go. Over 30 million Chromebooks were shipped in 2020, many of which went to students or directly to schools. In 2018, Chromebooks accounted for more than 60 percent of computers in US schools. Security features are a big draw; not only is ChromeOS less likely to be targeted by virus attacks than Windows computers (for now), but Google's design ethos included strong security measures. User error is the most common cause of digital security breaches, and ChromeOS has design choices built-in to minimize opportunities for users to mess up.

Though not the silver bullet for online security that Google would like you to think, Chromebooks are undeniably a safer and more streamlined way to introduce children to the digital world. Many kids' first encounters with technology are their parents' phones and tablets, so ChromeOS offering a familiar Android-enabled environment makes perfect sense. Upon first setting up a new Chromebook, you'll be given the option to set up a child-friendly profile, which allows a parent to easily set safety limits.

For adults, Chromebooks still have their advantages, but we're not convinced they're a viable competitor to Windows—not yet, anyway. They're improving fast, arguably faster than laptop hardware, which is beginning to stagnate. In another five years, the market could be in a different place, with Chromebooks potentially securing dominance thanks to their wallet-friendly pricing and idiot-proof software. Needless to say, we're curious to see what happens next. ⏻

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GETTING CONNECTED

Before there was the internet, there was the ARPANET. *Ian Evenden* speaks to some of those who were there, and discovers how they set about building something that had barely been imagined

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THE IDEA OF A NETWORK which spans the entire world is not a new one by any means. As far back as 1900, Nikola Tesla was dreaming of wireless power and message transmission, though sadly despite his claims, the chances are the wireless power part of the system would never have worked.

Thinkers and theorists kicked the idea around for much of the early 20th century, coming up with ways that information could be stored and accessed long before the technology to build them was actually available. MIT computer scientist and later ARPA office head, JCR Licklider, put forward the somewhat optimistic idea of an 'intergalactic computer network' in the early 1960s, but his work did a lot to ground the idea in reality instead of science-fiction. His ideas about an all-encompassing computer network contain almost everything the internet is today, including the cloud, simple user interfaces, AI, and 'time sharing'—the idea of a central server accessed via several terminals at the same time.

Another concept is that of packet switching, breaking a stream of data down into parts, each with a header detailing where it's going, that allows network hardware to make sure it ends up in the right place. This allows multiple computers to communicate on a single network, the data passing through routers that can decide the best route. This again came about in the 1960s, as part of research into fault-tolerant networking at the RAND Corporation, funded by the US Department of Defense, and through independent work by British scientist Donald Davies, who coined the term 'packet switching'.

Only once all these concepts are in place do you have the origins of the ARPANET, the precursor to today's internet. In 1966, at the United States Department of Defense's Advanced Research Projects Agency, or ARPA—better known today as DARPA, the Defense Advanced Projects Agency—a project was initiated to allow access to remote computers. Much of the work was carried out at UCLA and Stanford Universities.

Today, we have a network of networks, known as internetworking, but it took until 1969 to connect the first two computers. Work continued on protocols, culminating in the Network Control Program, led by Steven Crocker. NCP was the predecessor to TCP/IP, which was proposed by Vint Cerf and Robert Kahn in the early 1970s. The document setting out its initial specification contains the first use of the word 'internet'. Other protocols developed by Crocker's Network Working Group include TELNET, FTP, and SMTP. Finally, in 1983, ARPANET transitioned to using TCP/IP, and the modern internet age began, capped off by the invention of the World Wide Web by Sir Tim Berners-Lee at CERN in 1990.

However, in this feature, we're going to concentrate on the early structure and hardware rather than the front-end of the internet. Building the ARPANET required many different technologies to mesh in ways that, up to this point, hadn't been considered. When you're striking out into unknown territory, failures are to be expected, but the story of the ARPANET and internet is one of gradual improvement and expansion over time, once the initial period of explosive innovation was out of the way. We may have Web 2.0 and Web3, but down below, the cables and routers remain much as they were.

Amusingly for anyone who's ever used a computer, at least, the first message transmitted over the ARPANET in 1969 was truncated by a hardware failure. Only the 'LO' characters of LOGIN arrived at the target computer in Stanford, California, having been sent from UCLA, 350 miles away along the I5, with a full connection coming an hour later after some frantic debugging. Let's hope we make it through the next six pages.

ARPA WAS NEARLY BEATEN TO IT by the British, who from 1968 had a local area network of their own, the NPL Data Communications Network operated in London's National Physical Laboratory. It was based on designs by Donald Davies, the inventor of packet switching, and operated until 1986. Davies' ideas included a national commercial data network and, in 1966, his team produced a design for the laboratory network, including the concept for an 'interface computer' we'd call a router.

The NPL ideas were presented at the Symposium on Operating Systems Principles, a conference held in 1967 in Gatlinburg, Tennessee. The plan for ARPANET was also presented there, by Larry Roberts of ARPA, and he took away with him many of Davies' concepts, including the speed at which it should operate. ARPANET was originally designed to run at a transmission rate of 2.4kbit/s, but this was upgraded to 50kbit/s after NPL's remarkable 786kbit/s line speed.

Independently, Paul Baran of the RAND Corporation had come up with a similar idea to packet-switching, published in his papers titled 'On Survivable Communications', but called the packets 'message blocks'. However, his work lacked Davies' breakthrough idea that computer network traffic comes in bursts, not a constant flow like a phone conversation. It was this, along with the ability of the routers (known as IMPs, or Interface Message Processors) to route traffic around failures as long as a path could be found, that fed into one of ARPANET's disputed design goals. Baran's work was meant to survive and adapt in the event of a nuclear attack. Was ARPANET?

On the 'no' side is Charles Herzfeld, ARPA director 1965-1967, who wrote "The ARPANET was not started to create a Command and Control System that would survive a nuclear attack, as many now claim... Rather, it came out of our frustration that there were only a limited number of large, powerful research computers in the country and that many research investigators, who should have access, were geographically separated from them."

This sounds extremely altruistic, but is countered by Stephen J Lukasik, director of DARPA (it gained the 'D' in 1972 and lost it again in 1993, only for it to return in 1996) from 1970 to 1975, who said: "The goal was to exploit new computer technologies to meet the needs of military command and control against nuclear threats, achieve survivable control of US nuclear forces, and improve military tactical and management decision making."

Whether it was deliberate or not, the ARPANET ended up being inherently survivable thanks to its distributed nature and the ability to recompute routing tables to take account of nodes that suddenly stop responding. "One of the questions that gets asked and statements made is that this was a defense department project and it was the Cold War, so it must have been motivated by nuclear survivability," says Steve Crocker, who formed the Networking Working Group with Vint Cerf in 1969 as a UCLA grad student. "The short answer to that is 'no'," he says. "But the long answer is a bit more complicated."

We like a complicated answer, so let's have it. "In the funding process from a multi-layered bureaucracy, there's a lot of latitude at different levels," says Crocker. "And so, depending upon how much you're spending and what buttons you're pushing, some things take place without a great deal of major focus and other things rise to the level of national prominence, and get sorted out in the newspapers and in Congress.

"Fundamentally, this network was motivated by how you communicate across laboratories, how you foster interactivity, how you make computers more useful and do that in a distributed sense. On the other hand," Crocker says, "it was also evident that, since this was being funded by the Department of Defense, there's a question of its military relevance. The vast majority of military communications have nothing to do with weapons, it's how do you know where all your people are? How do you know whether you've ordered enough toilet paper? Lots of planning documents, a big bureaucracy that runs on communications. So, to justify the project in terms of how it will affect military communications is easy in a broad sense. On occasion, there were discussions about how someday in the future, this technology might be useful for deciding how to build future survivable networks.

The IMP team at Bolt Beranek and Newman. Robert Kahn is fifth from the left, in black.

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"That allowed some people to say, 'Okay, it might be helpful for nuclear survivability', and the person listening might be a senior person who says 'We have to spend money on that'. If you ask, 'If we had been trying to build a nuclear-survivable system, what would we have done?', then you look at the problems we focused on, there are big differences. But you can peel that apart, and ask, 'Are we using this technology for nuclear-survivable networks today?"

By coincidence, Crocker went to the same high school as Vint Cerf, who briefly worked on the Apollo program before moving to UCLA and the laboratory of Professor Leonard Kleinrock, where the first two nodes of the ARPANET were connected. It's the same school as Jon Postel, who was involved in the development of the internet domain system at UCLA and directed Cerf and Robert Kahn to develop what's now known as Transmission Control Protocol, TCP/IP.

INTERFACE MESSAGE PROCESSOR

UCLA's Interface Message Processor (IMP) is pictured in a storage closet, where it had been hidden for over 20 years.

ONE MILLION DOLLARS

On his desk in ARPA HQ in Virginia, the agency's director of information processing techniques, Bob Taylor, had three computer terminals, one each for the separate computer systems ARPA was funding. One was in Santa Monica at the System Development Corporation, one in Berkeley at the University of California, and one at MIT. "For each of these three terminals, I had three different sets of user commands," Taylor was quoted as saying in the *New York Times*. "So, if I was talking online with someone at SDC, and I wanted to talk to someone I knew at Berkeley, or MIT, about this, I had to get up from the SDC terminal, go over and log into the other terminal and get in touch with them. I said, 'It's obvious what to do—there ought to be one terminal that goes anywhere you want to go'. That idea is the ARPANET".

Taylor managed to get a million dollars redirected from a ballistic missile budget and hired Larry Roberts as program manager. At a design session in April 1967, Roberts proposed that mainframes could connect to one another directly. This would take computing capacity away from the mainframes and dedicate it to network processing, so a counter-proposal was made by Wesley Clark, the man often credited with designing the first modern personal computer, who suggested mini-computers should act as interfaces instead. The ARPANET plan was modified, and the mini-computers named Interface Message Processors (IMPs).

This idea was taken to Tennessee for the Symposium on Operating Systems Principles in October 1967, after which Davies' packet-switching ideas were absorbed into the project. Roberts later said ARPANET and other packet switching networks from the 1970s were similar in nearly all respects to Davies' 1965 design.

The specification for the IMPs was finalized the following year, and a request was sent out to 140 computer companies asking them to submit quotes for building the network. So outlandish was the idea that only 12 replied, with four of those considered as 'top-rank' contractors. In the end, only two quotations were considered and the job was awarded to a team from Bolt, Beranek, and Newman (BBN), led by Frank Heart and Robert Kahn, who'd completed a Ph.D in electrical engineering at Princeton in 1964. He worked at BBN, then moved over to ARPA's Information Processing Techniques Office where he implemented the SATNET early satellite network.

That lab brought together two previously distinct disciplines; computer science, of which there were many practitioners from the universities, and communications. "That was me,"

This building in Arlington, Virginia, was DARPA HQ until 2009, when it moved its operation closer to the Pentagon.

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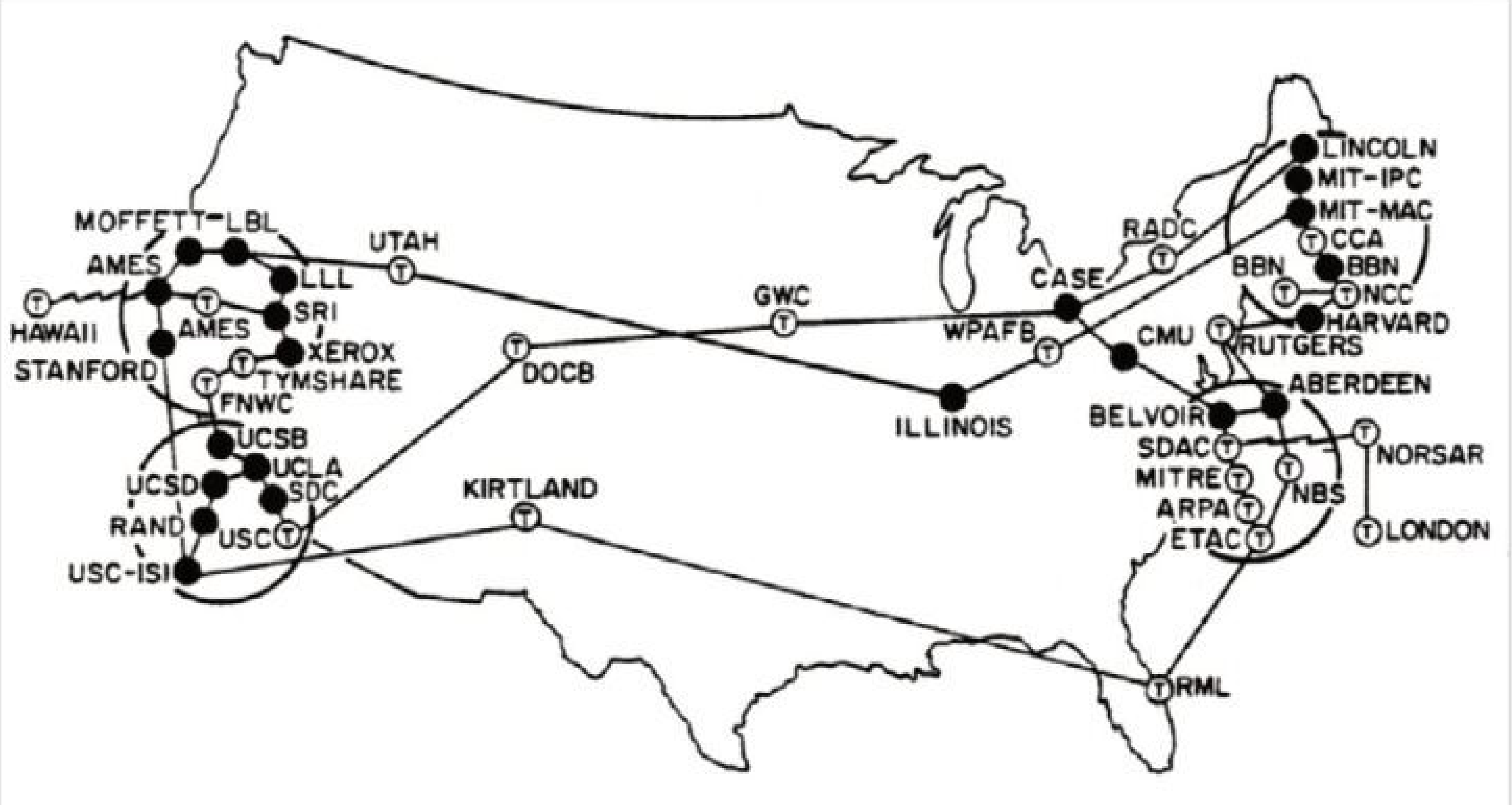
says Kahn. "I was the only serious communications person involved. What we were trying to do was support ARPA's interest in getting computers to work together to figure out how we can build something that would be efficient, effective, and rapid for computers to communicate, because the telephone network was poorly adapted to that. It took 10 or 20 seconds to set up a call, and if all you had to send was 1,000 bits, on a 50-kilobit line that could go in 20 milliseconds. The existing telephone system was inefficient for that purpose. So the question was, how could the telephone network be reinvented in some other fashion. And that's what DARPA laid out as a project, to develop a packet-switched network. It was something I'd been working on, without knowing DARPA was interested."

Crocker picks up the story: "During the 1950s and much of the 60s, the notion of a computer was something like a factory. You wanted to keep it busy because it was a big, heavy, expensive piece of equipment. The vast majority of computing that took place, particularly in the larger places where you had a mainframe serving a campus or business or government agency, was to keep it busy. That led to batch processing, where you stacked up your programs, and went away, and later in the afternoon or the next day, you would get back the answers. Unless you had a bug in your program, in which case you have to go and fix the bug and resubmit it. The idea of interactive computing, where you interact with it and it serves you, as opposed to us serving it and keeping it busy, had sprouted, but was still contained. In the mid-1960s there were laboratories that were already well funded, that all shared this notion of interactive computing.

"ARPA was heavily focused on interactive computing," Crocker continues. "Everything from better time-sharing systems on the one hand to the creation of artificial intelligence technology, to fancy graphics, to new architectures for computers that led to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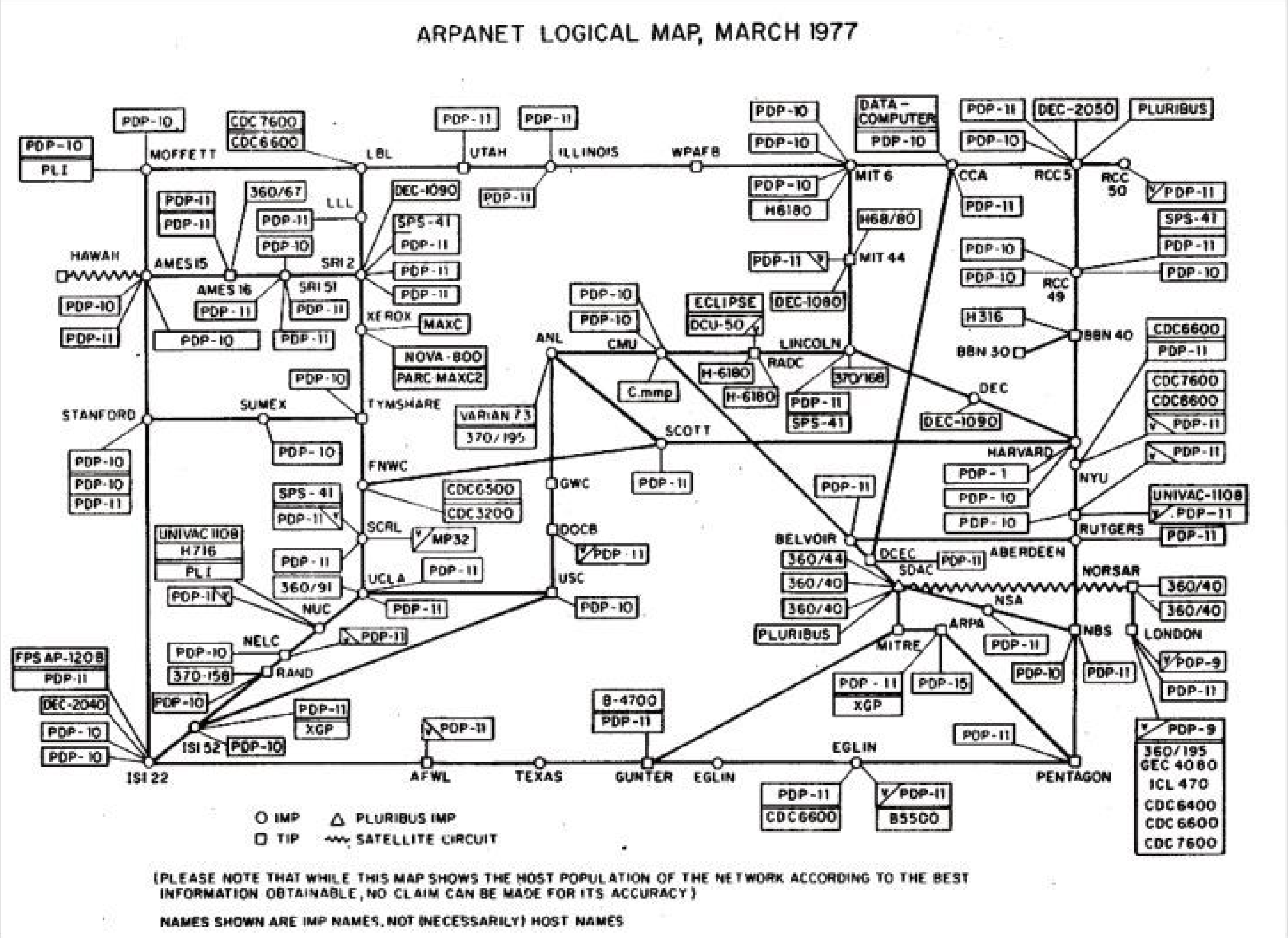
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LLL
XEROX
TYMSHARE
SUMEX
STANFORD
FNWC
SCRL
UCLA
NUC
NELC
RAND
ISI 52
ISI 22
AFWL
TEXAS
GUNTER
EGLIN
EGLIN
ANL
GWC
DOCB
USC
CMU
SCOTT
RADC
LINCOLN
MIT 44
RCC 49
BBN 40
BBN 30
DEC
HARVARD
NYU
RUTGERS
BELVOIR
DCEC
SDAC
ABERDEEN
NORSAR
NSA
ARPA
MITRE
NBS
LONDON
PENTAGON
○ IMP
□ TIP
△ PLURIBUS IMP
SATELLITE CIRCUIT
(PLEASE NOTE THAT WHILE THIS MAP SHOWS THE HOST POPULATION OF THE NETWORK ACCORDING TO THE BEST INFORMATION OBTAINABLE, NO CLAIM CAN BE MADE FOR ITS ACCURACY)
NAMES SHOWN ARE IMP NAMES, NOT (NECESSARILY) HOST NAMES

Maps of the ARPANET at the peak of its operations and of the ARPANET nodes show how the system expanded during the 1970s.

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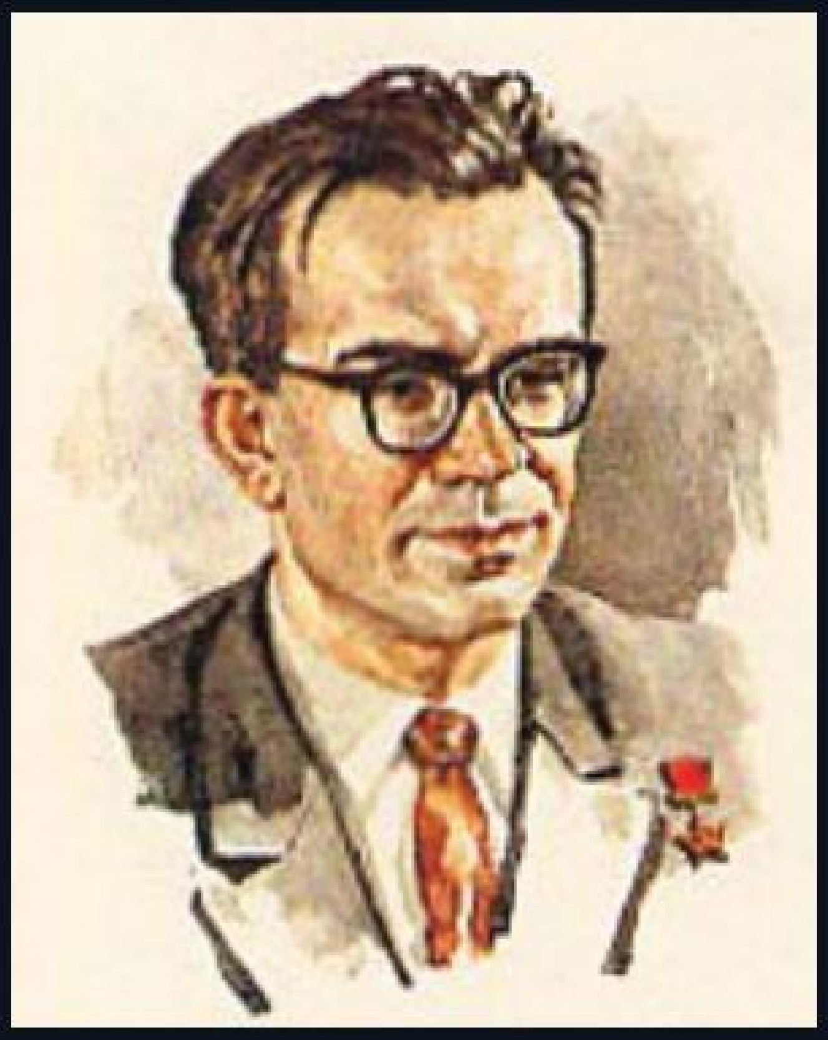
THE RUSSIAN NETWORK



During the Cold War, the Soviet Union was building its own network too. Known as OGAS (National Automated System for Computation and Information Processing) it began in 1962 but was shut down in 1970 due to a lack of funding.

Computer networks had been proposed in the USSR before, but the military never liked the idea of having to share information with civilians. Victor Glushkov (pictured above), a mathematician and director of the Computational Center of the Academy of Science of Ukraine, proposed OGAS in 1962, as a large computing center in Moscow with up to 200 nodes in major cities and 20,000 local terminals across the country, all connected using existing telephone infrastructure.

The system would be used, among other things, for electronic payments, pushing the Soviet Union toward a cashless economy. While some saw it as unnecessary centralized control, it was bureaucratic infighting that ensured OGAS would fail, as projects run by the Central Statistical Administration were seen as a threat to the Ministry of Finance run by the powerful politician Vasily Garbuzov. Glushkov's requests for funding were turned down, and political interest in the network waned.

The USSR did manage to create a civilian network, Academsnet, in 1978, but only the Leningrad section of the network was completed by the time the Soviet Union fell. It joined the nascent internet in 1982, using the X.25 protocol via a link to Austria, and maintained satellite links with Cuba, Mongolia, and Vietnam.

The Russians weren't the only ones linking their computers together. The French created CYCLADES in the early 1970s, expanding to 20 nodes in 1976 with connections to NPL in London, and to other European computing hubs.

Even Chile wanted in on the network action, running Project Cybersyn (cybernetic synergy, known as Synco) between 1971 and 1973 to manage the newly socialist central economy. It consisted of a national network of Telex machines linked to one mainframe that ran economic simulations and custom software to check factory performance. Sadly, the military coup in 1973 caused the project to be abandoned and the operations room destroyed.

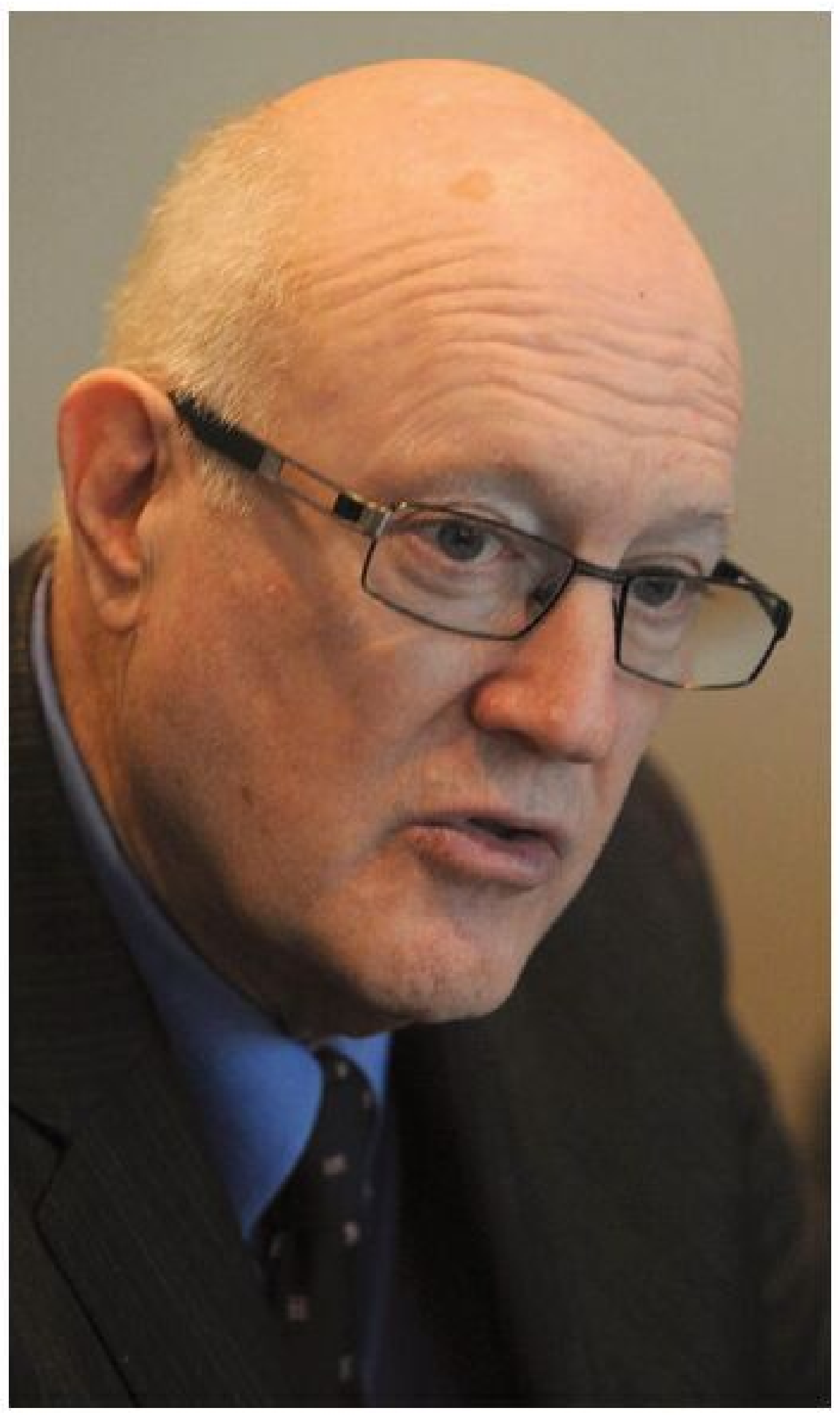
supercomputers. A full spectrum of cutting-edge computer science research. So the ARPANET project is not viewed as a communications thing, but a natural evolution of extending the interactive computing environment as a way of knitting together all of these laboratories so that they can exchange information, so that the computers can cooperate on the same problem if necessary, so people can collaborate."

OPEN GATEWAY

BBN's plan made use of the IMPs as gateways that connected local resources such as mainframes. They handled all the network calculations and were connected using leased lines via modems at 56kbit/s. The first-generation IMPs were ruggedized Honeywell DDP-516 computers, each with 24KB of magnetic-core memory. The 16-bit DDP-516 operated mostly at 2.5MHz, with some parts able to reach 5MHz, and was the first mini-computer to retail for less than $10,000.

In its rack-mounted configuration, it weighed 120lbs and drew 475 watts, but the IMP was housed in a metal cabinet the size of a refrigerator with 24 indicator lamps on the front showing the state of the network channels. Despite being introduced in 1969, a DDP-316 was still operating in 2000, monitoring the reactor core temperature at a nuclear power station in Essex, United Kingdom. It only stopped working when its internal 160KB disk failed.

Each IMP could communicate with four local hosts and six remote IMPs via leased telephone lines, and the first four nodes in 1971 were UCLA, Stanford Research Institute, UC Santa Barbara, and the University of Utah School of Computing. The abortive first message, 'LO', was sent from the SDS Sigma 7 computer at UCLA to the SDS 940 at Stanford. A student programmer, Charley Kline, attempted the link at 10.30pm on October 29th, 1969 but the first successful login was subsequently achieved about an hour later.


Steve Crocker speaking in 2012, while he was chairman of ICANN.

A permanent link between the IMPs at UCLA and Stanford was established on November 21st, 1969 and the full four-node network was complete by 5th December the same year. What it didn't have yet, however, was much in the way of network applications, and used something called the 1822 Protocol, named for the BBN report number that specified it. Messages sent by 1822 used numeric network addresses and were guaranteed to be transmitted reliably. In the event of a failure, a message was sent back to the originating machine indicating there was a problem.

The Network Control Program came next, providing the middle of the network stack and a firmer base for things like file transfer and email. The @ symbol at the center of email addresses was chosen by programmer Ray Tomlinson in 1972.

Crocker led NCP's development, while other members of the Network Working Group worked on TELNET, FTP, and SMTP. In March 1970, an IMP at BBN in Cambridge, Massachusetts, was connected to the network, and by September 1973 there were 40 nodes. A satellite link to the NPL network in London was considered, but University College London was chosen instead. In June 1973, Kahn's SATNET connected ARPANET to the Norwegian Seismic Array (NORSAR, used to detect nuclear explosions through seismic waves), via a downlink in Sweden, then via cable to UCL and, eventually, to NPL, the first time two distinct networks had been connected. Internetworking was go, albeit at 2.4kbits/s.

In an interview in 1988, JCR Licklider, head of the Information Processing Techniques Office at ARPA, remembered the difficulties of dealing with the British on the project: "When I was

The Internet Hall of Fame Inductees for 2012. Vint Cerf is fourth from right in the back row, Steve Crocker is fifth from right in the front row, with Leonard Kleinrock two seats to his left. Robert Kahn is represented by Patrice Lyons, next to Cerf.

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Robert Kahn in 2005, when he received the Turing Award for his contribution 'of lasting and major technical importance to the computer field'.

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[at ARPA in 1974-1975], we were trying to set up a satellite link with Britain, and to deal with the Post Office Telecommunications, who oversaw telephones in the UK back then, was just a totally different experience from anything else. They wanted us to buy insurance covering their whole plant, in case our IMPs set fire to their equipment, or something. It was really weird.

"Their worst fear was that somebody in Europe would call up, through some kind of a network, to a British telephone installation, and get through it into the Atlantic link and get to the United States, and somehow bypass the 15 cent toll. 'Christ,' I said, 'this is just a research and development thing. If we can make it work, if it turns out to be a great idea, then we can figure out about rates'. We desperately needed to extend the ARPANET link to Stuttgart, to some American military base down there—and they wouldn't let us have the one little link."

"The specification for the ARPANET was a 1,000-character message in half a second," says Crocker. "Not in two minutes, not tomorrow or something like that. So it wasn't like the US mail system. This was a novel approach to the use of the underlying communications line based upon packet switching and, fortunately, ARPA had enough money and the latitude to do this as an experiment without a lot of interference or legal issues. That was a huge consciousness-raising event, in the sense of once that project got going, it triggered big reactions from the French, the Canadians, and the British. Everybody said 'we have to have a network too'. And then the race was on."

TIPPING THE BALANCE

The year 1971 also saw the arrival of Terminal Interface Processors (TIPs) which allowed users to dial into the ARPANET, accessing databases stored hundreds of miles away without having to travel. Many TIPs were Honeywell 316 computers, with up to 56KB of RAM, each of which could support up to 63 ASCII-based terminals. We've only mentioned Honeywell machines so far, but part of the challenge of building the ARPANET was to transfer data without knowing the underlying architecture of the machine it would be displayed on. This slowed things down, as interface hardware and network software were developed for the DEC-10, PDP 8 and 11, IBM 360, Multics (an early time-sharing operating system for General Electric mainframes), the Honeywell machines, and more.

In 1972, Kahn undertook the first public demonstration of the ARPANET at the International Conference on Computer Communications at the Hilton in Washington DC. The idea was to install a packet switch and a TIP in the basement of the hotel and invite conference attendees in to have a go. All the big names were there—Crocker, Postel, Davies, and lots of others we've had to leave out for the sake of brevity, many from overseas.

Postel had a demo cooked up that saw him retrieve a file from a computer in Boston via a host at UCLA, and print it out there in the hotel. A glitch saw the file sent, not to the printer, but to a robotic turtle built by MIT that demonstrated how a machine could follow a computer program and move. Unaccustomed to the input designed for the printer, the turtle began jumping up and down, twitching and jerking.

And that wasn't the only thing to go wrong. One user, trying to follow instructions but instead attempting to access a computer that wasn't operational, received a 'Host Dead' error and cried out, "Oh my God! I've killed it!" Two other users logged on to a Utah machine and started a text chat, only to discover they were sitting close to one another. There were early chatbots too, set up to talk to one another as if a doctor was talking to a patient.

Hundreds of people tried the new technology, but the biggest failure came when Robert Metcalfe—later to co-invent the Ethernet—was giving some AT&T VPs a guided tour. The TIP crashed and, despite being down for no more than 20 seconds, this left an impression on the telephone company suits. AT&T was providing the data link for the demonstration but believed its circuit-switching technology was superior to packet-switching. "They made no point of hiding their joy," Metcalfe is quoted as saying in James Pelkey's *A History of Computer Communications 1968-1988*. "Because this confirmed for them that circuit switching was better and more reliable than packet switching, which was flaky and would never work. I had been working on this for two or three years and it really hacked me off." Despite AT&T's skepticism, the demonstration was held to be successful, and the conference saw the founding of the International Network Working Group, under the leadership of Vint Cerf.

It was the following year, in 1973, that the first illegal online act was perpetrated. As a government-funded network, the use of it for personal reasons was prohibited, but UCLA's Professor Kleinrock sent a request for the return of his electric razor, which he had left behind after a meeting in the UK. It would only get worse: in 1978, Gary Thuerk of DEC sent a mass-marketing email to 400 recipients, in breach of the rules in place at the time. He claimed it resulted in $13 million in sales.

ARPA was a research agency and so when ARPANET was declared fully operational in the summer of 1975, the Defense Communications Agency took control. At about the same time, despite ARPANET having had passwords protected by a polynomial hash algorithm since 1971, encryption devices were added to the network to support classified communications, the first ones manually keyed, with later iterations supporting the automatic management of cryptographic keys.

ARPANET kept growing and evolving, however, standardizing around TCP/IP in 1980 (the same year that USENET went public at the University of North Carolina and Duke) thanks to a DoD directive. UCL and the seismologists at NORSAR left the network in 1982 but kept a connection to SATNET, the Atlantic Packet Satellite Network that was linked to both ARPANET and the PRNET packet radio network in 1977. All of these were funded by ARPA, and many were built by BBN.

ARPANET shrank significantly in September 1984, after the network was restructured to send unclassified military traffic onto its own network, MILNET. This saw 68 of ARPANET's 113 nodes move to the new network, though they could still be accessed via a small number of gateways configured so that the two networks could be separated if needed. Researchers used ARPANET as an internet backbone, but its days were numbered.

In 1985, the National Science Foundation Network (NSFNET) was established, providing access to five supercomputing centers and the National Center for Atmospheric Research (NCAR) using a 56kbit/s link (expanded to 1.5Mbit/s by July 1988 and 45 Mbit/s in 1991) and using TCP/IP. It became active in 1986, connecting Princeton University, Cornell University, San Diego, Pittsburgh, and Urbana-Champaign in Illinois, all recently created supercomputing hubs, and NCAR in Boulder, Colorado. This became the main network backbone for government agencies and university staff, the combination of NSFNET and ARPANET becoming known as 'the Internet'.

Gradually, ARPANET was replaced and left obsolete, with NSFNET faster and more dominant in every way. ARPANET was decommissioned in 1990, its IMPs and TIPs phased out by July that year, and its traffic moved to NSFNET. A year later, Senator Al Gore's High-Performance Computing and Communication Act was passed, based on a proposal by Leonard Kleinrock that suggested the building of the networks, services, hardware, and software required to make vast amounts of digital information available to anyone. The 'information superhighway' championed by Gore who, despite a tendency to be overly enthusiastic and struggle to explain things, had been involved with computers since the late 1970s, sounded much like the World Wide Web and digital commerce/streaming services we know today.

"If you look at the genesis of networking," says Kahn, "it started with the ARPANET but broke out into multiple network environments with the introduction of the packet radio net and the packet satellite net, which used Intelsat IV [1970s geostationary communications satellites]. Suffice to say, the ARPANET is gone, but what remains are the notions of packet-switching and rapid interactive networking. It fundamentally affected the communications industry, because the economics of fiber across the Atlantic offered an alternative to Intelsat. The packet radio net morphed into today's ground-based wireless systems.

"The technology evolved to become the internet we have today in large part due to the social structures that we put in place which were needed to allow the network to evolve. It's not enough to build a piece of technology and put it out there when the technology itself is evolving so rapidly. You need a way of constantly augmenting, improving, expanding, and increasing it," Kahn continues.

"When I was in DARPA, and we were going down the internet path, I remember thinking then that we needed the community more involved, so I signed the paperwork to form the Internet Society and Vint Cerf became its first president. I was named head of ICANN [a non-profit organization set up to ensure the stable and secure operation of the internet] for a while, as was Steve Crocker later on. All those social structures were, and are, as essential to the internet as the technology."

ARPANET leaves one more ripple in the enormous pond that is today's internet, the .arpa top-level domain, now reserved for technical infrastructure purposes, although a 'backronym' has since been created for it—the Address and Routing Parameter Area. Originally a temporary domain for naming ARPANET computers, it ended up being too difficult to remove, and so it remains today. You can't register a domain there, and it mainly fulfills functions related to reverse IP address lookup, domain mapping, or DNS. However, it's a little bit of the internet's history, hidden in plain sight.

WHAT HAS DARPA EVER DONE FOR US?

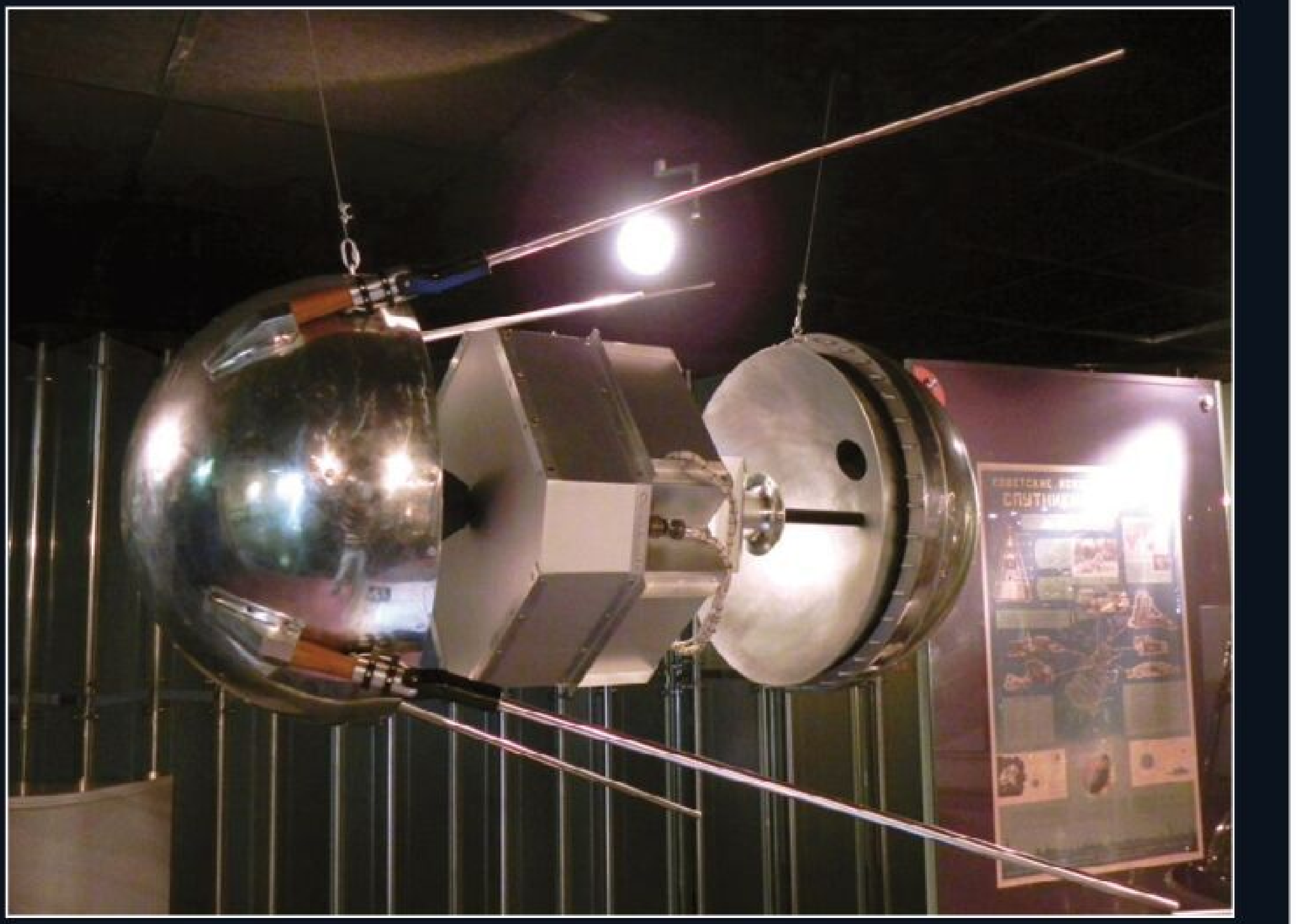
"DARPA was created when Sputnik went up," says Crocker. "The US government got caught flat-footed in its space program and the agency was created to prevent technological surprises. The first thing it did was to gather the pieces of the space program together and then NASA was spun out of that."

It was an exciting start for the agency responsible for developing emerging technologies for use by the military, and its $520 million budget in 1958 ($3.427 billion in 2019) reflects this. Essentially, it takes new ideas, shakes them, sees what military applications drop out, then invests in making these happen. As a side-effect, interesting civilian and medical applications of technology tend to get discovered too.

Take GPS and weather satellites. Both developed with DARPA investment to make it easier for tanks to roll across the Cold War battlefields of eastern Europe but now making it possible to avoid the traffic tailbacks at the mall.

Then there's the PC, surely the apogee of the interactive computing doctrine of ARPA. As the architect of the LINC at MIT's Lincoln Lab, the first minicomputer and the forerunner of the PC, physicist Wesley Clark is one of the fathers of the personal computer and also the man who suggested ARPANET use separate routers from the mainframes it was linking.

The LINC was a 12-bit transistor-based computer designed for researchers at the National Institutes of Health in 1962. Its display was a pair of oscilloscopes, each about 5-inch square. It could be programmed with a keyboard and a control panel full of knobs and switches, it cost $40,000 and shipped around 50 units. The designation 'minicomputer' merely meant it was smaller and cheaper than a mainframe, and the LINC was housed in a wooden cabinet six feet tall and 20 inches across. It contained a 400kb rewritable tape drive and displayed characters on its screens using a 4x6 matrix of pixels—one of the lowest resolution character sets designed.


A mock up of the Sputnik satellite with the case opened. This was the first man-made object launched into earth's orbit.

DARPA is also involved in the fight against Covid-19. The agency began investing in nucleic acid vaccines back in 2011. Instead of delivering a dead or weakened form of a pathogen to the body, these vaccines deliver the genes that can make an antigen, triggering a protective immune response. In 2016, its Pandemic Prevention Platform program was looking into producing antibodies against diseases such as influenza, Zika, and MERS, meaning it could pivot easily to Covid. The fruits of its labor eventually came to market as the vaccine developed by Moderna.

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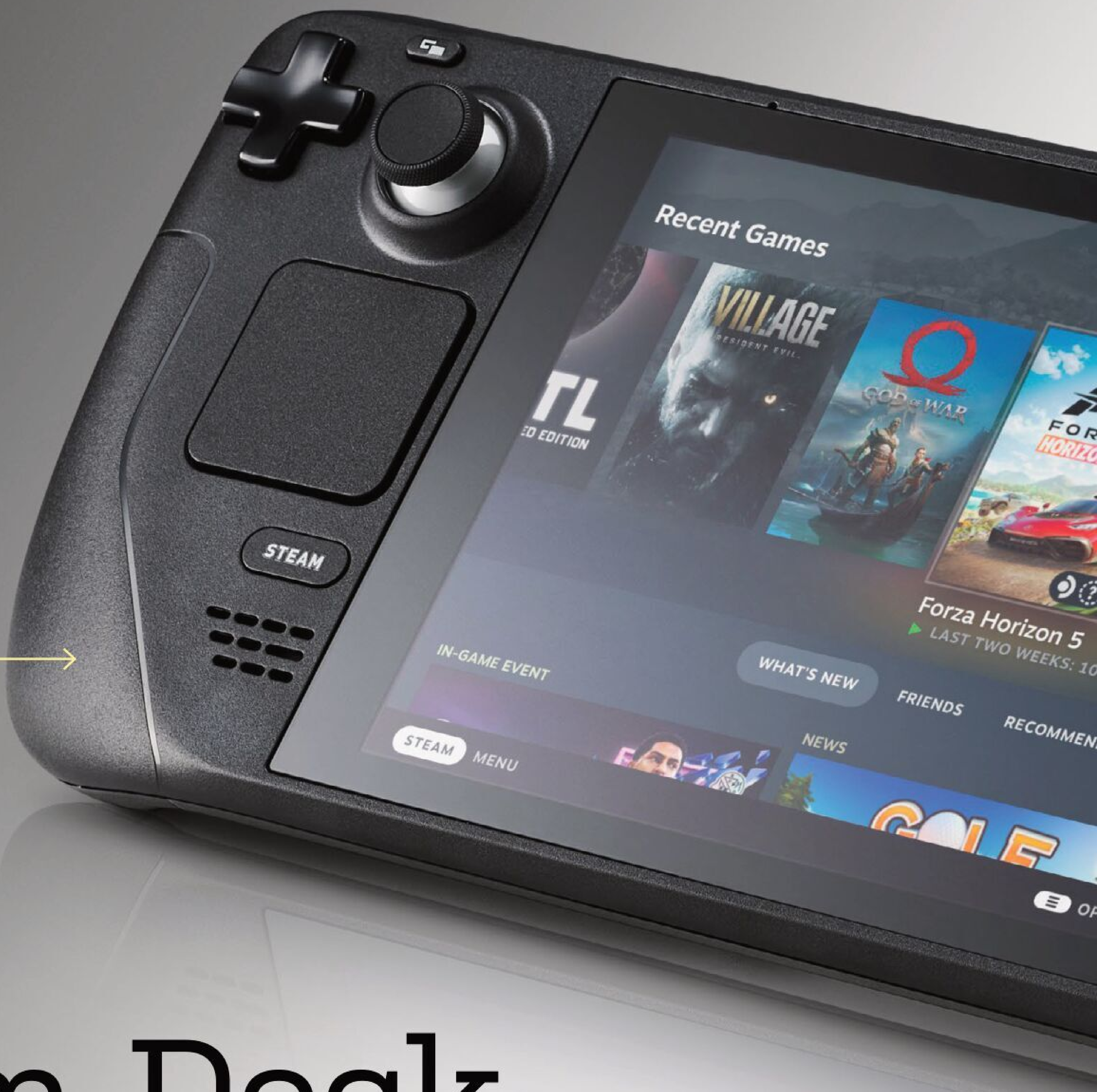
CENTERFOLD

PERFORMANCE GEAR LAID BARE



1 UPGRADABILITY

Now that we have a finished unit, we've dug deeper into the ins and outs of the retail Steam Deck. You can take the console apart using a Philips screwdriver, although Valve advises that the case will be less rigid and more prone to damage as a result. Joystick replacements and hard drive updates are simple enough, but we were disappointed with how tricky battery replacements are in comparison. To help extend the battery life, use mains power where possible.

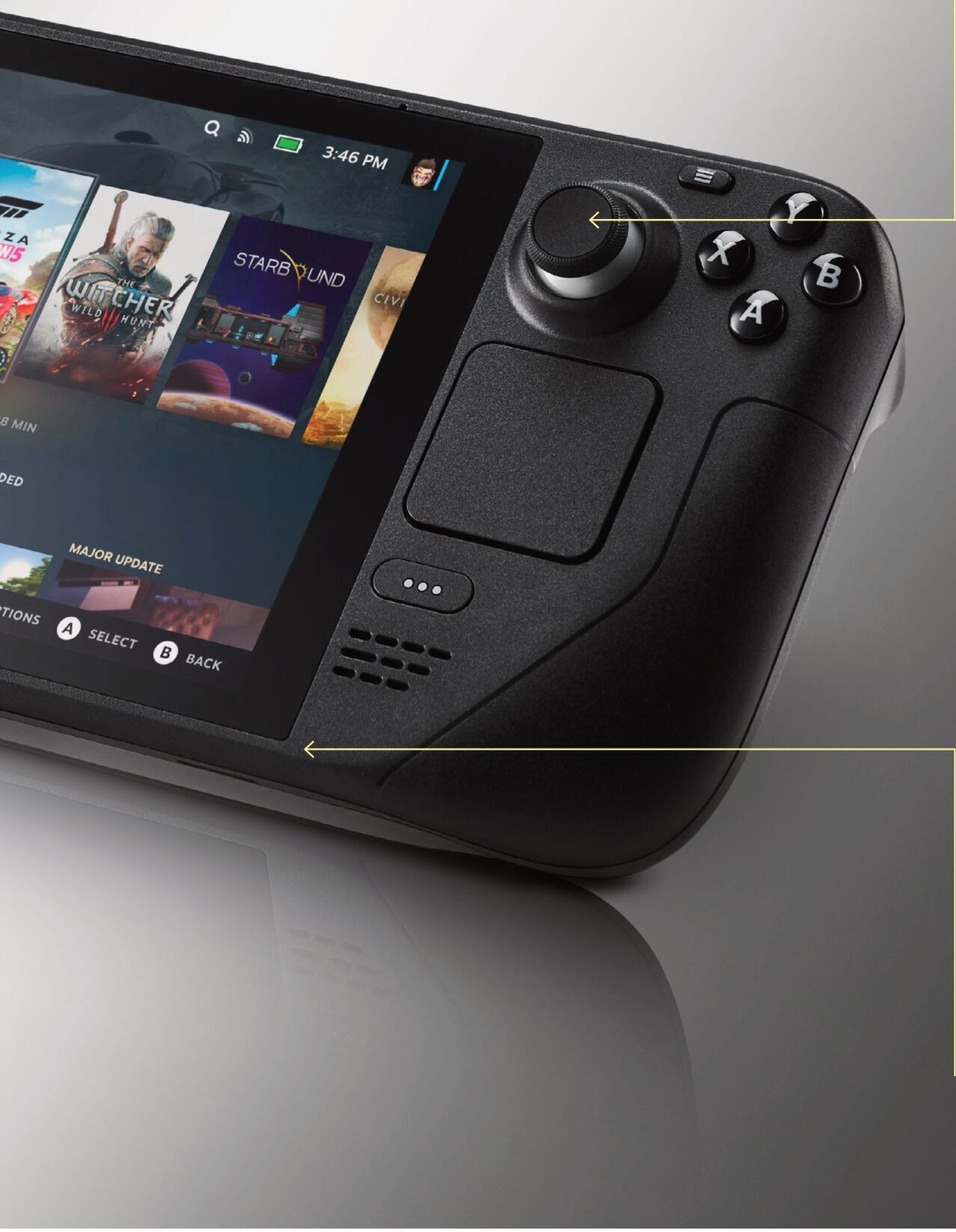
Steam Deck

THE STEAM DECK IS HERE! Well, it might be, if you were quick off the mark with your pre-order. Yes, rather than a big launch, it seems as though Steam Decks are going to be drip-fed into the market for the rest of the year. Thankfully, we were able to get our paws on the finished hardware this month, so we wasted no time getting it into the studio.

First of all, this is technically a portable console, but at 1.47lbs and nearly 12-inches across, it's not going to slip into your pocket unless your jeans are very baggy indeed. Other than the limited portability, though, we're impressed—the interface feels fairly comfortable, the screen is substantial and the AMD Zen 2 CPU and RDNA 2 GPU are impressively specced for the price.

What stands out at this stage is that the Steam Deck doesn't feel ready for primetime, yet. Some games work better than others, some drain the battery in under a couple of hours, and some won't work at all. We expect a lot of this will be ironed out once we're able to install Windows but, for now, it's a roll of the dice as to how well any game works.

Valve should be applauded for how easy it's made the console to modify and fix, though. Anyone's who's ever mended a laptop should be able to upgrade the internal SSD immediately or replace the thumbsticks if they begin to drift over time. We'll have lots more on the Steam Deck in the coming months, but here's what we learned so far from our limited time with the finished hardware. **–GUY COCKER**



2 TOTAL CONTROL

The Steam Deck has more control options than we've ever seen on a portable console. There are all the buttons, triggers, and sticks you'd expect, but Valve has added touch-sensitive panels to replicate the movements of a mouse. The thumbsticks are also touch-capacitive, so rest a thumb on the right stick and the Steam Deck will engage motion controls—handy for those players who might be more comfortable tilting away like they might do in *Mario Kart* on the Switch.

3 QUICK AS A FLASH

Every model of Steam Deck comes with an M.2 2230 slot, so you can drop in up to 1TB of SSD storage (or more, as Micron unveiled a record-beating 2TB 2230 drive earlier this year). Valve isn't recommending you upgrade the drive, but our good friends at iFixit showed how easy it is to do with just a screwdriver and a couple of spudgers. If you don't feel up to opening the console up, you can still throw a microSD card in without having to worry about any voided warranties.

MAC V

FOREVER FRENEMIES

The PC and Mac have been rivals for nearly 40 years, yet the Mac has never had the measure of the PC. Could the arrival of Apple silicon finally give the Mac the edge? *Jeremy Laird* investigates…

VS PC

THE 24TH OF JANUARY 1984. Our story begins with the launch of the Apple Macintosh 128K. In the intervening nearly 40 years, the Apple Mac has never been able to match the sales success of the PC but, when it comes to mindshare, the two platforms are on much more equal footing.

As it happens, the Mac had its best year ever in 2021, shifting just under 29 million units. If that sounds impressive, most estimates of overall worldwide personal computer sales last year, not including Apple Mac shipments, suggest a figure of around 325 million desktops, laptops and workstations. In other words, at its best, the Apple Mac isn't even one tenth as successful as the PC.

If comparing one company to an entire industry seems unfair, several of the bigger beasts in PC sales shift far more units than Apple. Lenovo alone sold 82 million PCs in 2021, HP's sales were 74 million units and Dell's 59 million. You get the idea. Whatever the Mac's merits, market domination isn't one of them.

Maybe not in sales but, in terms of technical and cultural influence, the contest has been much more competitive. Without getting bogged down in the debate over the origins of various graphical user interfaces, the 1984 Macintosh's virtual desktop metaphor predated the launch of the first version of Windows by nearly two years. Ever since, there's been a symbiotic relationship between the two mainstream computing platforms that has seen countless elements of software and hardware either mimicked or adopted wholesale by both sides.

Here in 2022, the Mac is currently going through one of its periodic overhauls, primarily thanks to the shift from Intel CPUs to chips designed in-house by Apple, a process that is due to be complete by the end of the year. By some accounts, the new Apple M1 chip family is revolutionary. Certainly, sales of Macs are on the up. All of which means it's time to revisit that time-honoured contest: PC versus Mac. Of course, we have a dog in this fight. But that doesn't stop us from appreciating the things that Apple gets right. In the end, there can be only one winner. Bring it on!

HARDWARE

Throughout the years, for better and for worse, the PC has remained faithful to the x86 line of central processing units. Indeed, an x86 CPU is central to the definition of what it is to be a PC. Meanwhile, the Mac has been architecturally more mercurial.

The original Macs ran Motorola 68000 series CISC chips, with the first major shift in CPU architecture coming in 1994 and the move to PowerPC RISC processors. That generation of Macs lasted another 12 years until Apple famously made the jump in 2006 to Intel x86 CPUs, ensuring the Mac was on a par with the PC in terms of performance and platform features.

In November 2020, Apple made what could be its final transition to processors designed in-house, known collectively as Apple silicon. We'll dig into the performance comparison in the next section, but suffice to say that Apple silicon is a huge leap forward over the Intel chips it replaced.

Of course, CPUs are just one aspect of the hardware comparison. For many users, build quality, features, and form matter just as much, maybe more. Historically, Apple computers tend to be better built and offer certain specific features or functionality that can't be had in other machines, while the PC counters with more choice and a wider range of forms and features.

That's pretty much how things are today. Few, if any, PCs can compete with the sheer physical quality of Apple's current desktop and laptop computers. Numerous PC manufacturers, for instance, have mimicked Apple's unibody laptop engineering, in which the main chassis is machined out of a single piece of alloy, typically aluminum. But none have created laptop PCs with the same rigidity and sense of hewn-from-solid-rock integrity as Apple's MacBooks.

Apple's latest MacBook Pro 14-inch and 16-inch systems also offer displays powered by mini-LED backlights with insane 1,600-nit peak brightness and exceptional image quality. They also have better speakers than any PC laptop. Likewise, the Mac Mini is one of the slickest mini desktop computers on the market and if there's a full-sized desktop PC that matches the sheer material quality of the current Mac Pro, we haven't seen it.

Likewise, because Apple has full control of the specifications of its computers, it can maintain certain standards. High DPI 'retina' displays and the visual clarity that comes with that are a good example. It's not that you can't have high DPI on the PC. But with a Mac, it's now standard where a display is included and therefore something you don't have to worry about or understand in detail. On the PC, it's far more hit and miss.

Yet, Apple's systems can't come close to matching the breadth of features and capabilities of the PC. One example is touchscreen functionality. Apple has decided that it knows best and so the Mac doesn't do touch. You simply can't have a MacBook with a touchscreen.

You also can't have a Mac with an OLED panel, a detachable screen, pen input, in tablet form, with RGB lighting, and until the recent update, even basic items like HDMI ports and card readers weren't in the Apple MacBook mix. As for the desktop market, the current Mac Pro is one of the last remaining Intel-powered Apple computers and is, therefore, due to be replaced imminently. It's a nicely engineered box and fairly configurable by Apple standards. But compared to the breadth of forms and the choice of components available for desktop PCs, it simply doesn't compare. Take graphics cards as one example. Currently, you can't have Nvidia GPUs in an Apple Mac.

Which is a sentiment that prevails generally. Apple's computers are fine machines. But if Apple doesn't sell the size or type of computer you're after, with the features and functionality you want, then you're clean out of luck. Meanwhile, PCs of pretty much any size, shape, and specification you can imagine are available. It's you, the customer, that gets to dictate the shape and spec of your machine. With Macs, Apple knows best.

INTEL CORE™ i9
i9-12900K
SRL4H

Intel's new 12th Generation Alder Lake CPUs are exclusive to the PC.

WINNER

PC

MAC

Apple Macs are more consistently high quality, but the PC has so much more choice in terms of systems, form factors, components and capabilities.

VALUE

Mac computers are often criticized for their punitive pricing. When you consider that a current Mac Pro starts at $6,000, it's not hard to see why. That's for a machine running an ancient eight-core Intel Xeon chip from 2019. But it's a workstation-class system and soon to be replaced. Compared with high-end workstations from the biggest PC brands, some Mac Pro configurations have been competitive and may be again when they move to Apple silicon later this year.

Apple's MacBook systems can offer decent value, depending on how you configure them, but that configurability is the problem. Macs offer few options and Apple charges prohibitively for ones that are available. Want to upgrade a MacBook Air from 256GB of storage to 512GB? That will cost $200. What about system memory or RAM? Add another $200 on the MacBook Air for the jump from 8GB to 16GB and what looks like a decent deal for the base $999 MacBook Air becomes $1399. Meanwhile, even an 8GB to 16GB upgrade for a PC like a Dell XPS 13 laptop costs around $100. Adding 8GB to a user-upgradeable laptop PC will cost less than $40.

SIRI vs. CORTANA

In the battle of voice assistants, the obvious winner is Apple's Siri, right? After all, voice control is most commonly used on mobile devices and last year Microsoft actually ditched its Cortana app for Apple iOS and Google Android devices. Cortana was also nixed on the Xbox console back in 2019.

Around the same time, Microsoft CEO, Satya Nadella, made it clear that Cortana was no longer going to compete directly with Siri or, indeed, Google Assistant and Amazon Alexa in the AI assistant market. Instead, Nadella saw Cortana becoming a more specialized service that integrated with

Two-in-one tablet devices, such as the Dell XPS 13, are exclusive to the PC as Apple's Macs don't do touchscreens.

Generally, the PC's flexibility means you can maximize your money, only spending on the things you really want. Again, you decide what goes into your PC and, in many cases, can choose to pay market rates for any given component rather than get gouged for upgrades by the system builder. The competitiveness and relative transparency of the PC market means that factory upgrade prices are often the same as individual components bought separately.

WINNER

PC

MAC

Some Macs are good value, but the PC is the king of bang for your buck.

OPERATING SYSTEMS

When Apple made the jump to Intel chips in 2006, Macs offered the best of both worlds. Apple started supporting dual-boot Intel Macs with both MacOS and Windows, via the BootCamp application and full driver sets for Windows on Macs. It was also possible to run MacOS on generic PC hardware during that era, albeit with dubious legality. But with the switch to Apple silicon, the two platforms have once again diverged.

In simple terms, MacOS versus Windows is a question of polish versus power. Apple's OS has always been slicker and more refined, at the same time offering arguably less control and autonomy to the user. Windows has offered greater configurability while being a little rougher around the edges.

An example of MacOS's superior polish involves UI rendering. Even in the latest builds of Windows 11, it's possible to drill down into menus and expose ancient dialogue boxes from the late 90s containing grey graphics and aliased fonts. Windows likewise still does a patchy job of scaling variable DPI settings.

MacOS also offers better integration with other devices, provided those devices are made by Apple. Because Apple controls everything across its product stack and only has to support a small range of products, it can ensure smooth interoperability across your computer, tablet, and smartphone. One example is Apple's Airdrop feature, which even PC aficionados have to admit can be handy.

However, there are also parts of the Windows interface we prefer. While both OSes offer support for multiple virtual desktops, desktop and app management is far more intuitive in Windows. 'Snapping' apps to fill half, a quarter or a third of the screen is easier, something Windows 11 takes a step further with Snap Groups, which allows you to jump between six different multi-window arrangements.

Windows' taskbar approach to app management is also quicker and more intuitive when it comes to switching between multiple instances of a single app and between different apps when multitasking. Beyond that, much comes down to personal taste. We prefer Windows File Explorer's approach to file listing and preview to MacOS's Finder, for instance. But that's a preference rather than an objective advantage for Windows.

DRAW

PC

MAC

MacOS is still more polished and slick, Windows that little bit more powerful and configurable.

Hi. I'm Cortana.

other voice assistants. In fact, while Cortana is part of Microsoft's latest client OS, Windows 11, it has been demoted in terms of its prominence. It's no longer part of the first-time boot 'experience' and the Cortana icon has been removed from the Windows 11 taskbar.

However, when comparing Mac and PC rather than smartphones or speakers, Cortana is still competitive with Siri. Both platforms offer similar headline capabilities, such as opening apps, changing settings, sending emails, and setting reminders. But, as it happens, Cortana does actually have a few unique capabilities that Apple's Siri lacks, including the ability to shut a PC down.

The repositioning of Cortana has also allowed Microsoft to partner with Amazon to integrate Cortana with Amazon's Alexa voice assistant. On the other hand, if you buy into the wider Apple ecosystem, such as running not only a Mac but also an iPhone, then you can benefit from having a consistent Siri-powered experience across your main computing and mobile devices.

© DELL, MICROSOFT

SOFTWARE

For built-in software, both OSes offer a huge array of utilities and apps. Mail clients, photo viewers, screenshot tools, contact managers, you name it, both platforms include it. As for features unique to either, Microsoft includes items such as Sticky Notes, Skype, and Xbox gaming, while MacOS has the GarageBand music app, a far superior video editor, and a full productivity suite, including the Pages word processor, Numbers spreadsheet, and Keynote presentation creator.

As for browsers, arguably MacOS has the edge both literally and figuratively. After all, Microsoft's Edge browser is available for MacOS as well as Windows, but Apple discontinued its Safari browser for Windows back in 2012. Meanwhile, alternatives such as Chrome and Firefox are available on both platforms.

Thanks to the far greater adoption of Windows PCs, the supporting ecosystem of third-party software is inevitably larger on the PC. There's little in software terms that doesn't exist for Windows. MacOS counters with one or two exclusive killer apps, such as Apple's own Final Cut Pro video editor.

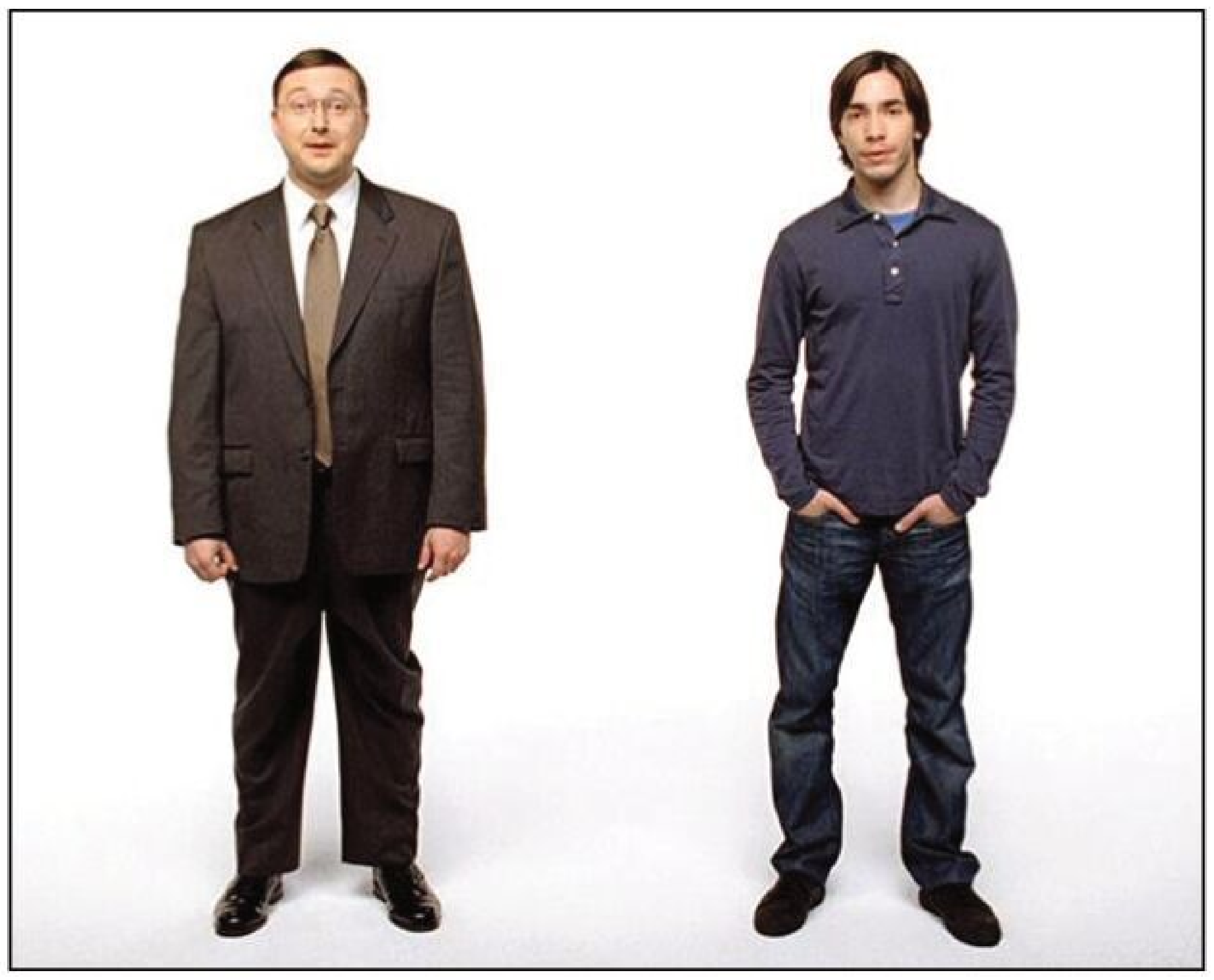
Some apps available on both platforms are also better integrated with and optimized for the Mac. Some would argue the Adobe suite of creative software falls into that category. Of course, that cuts both ways. The majority of serious business software is only available on PC.

WINNER

PC

MAC

MacOS has better built-in apps, but it's the epic Windows ecosystem FTW... for now.



Mac has always had better commercials but, ultimately, the joke is on Apple as the PC has dominated the market.

PERFORMANCE

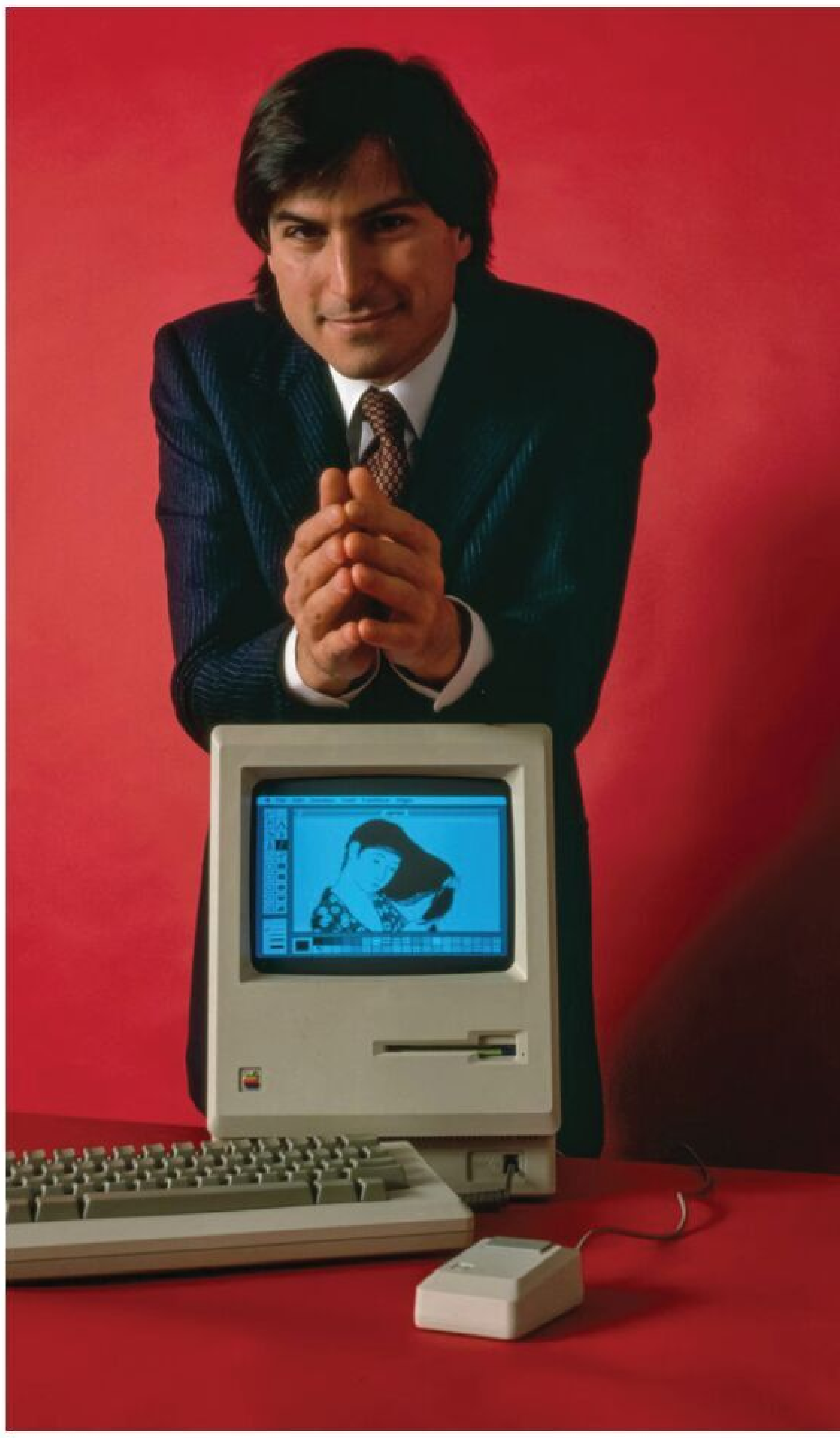
Has Apple's hot new in-house silicon, namely the M1, M1 Pro, and M1 Max made the Mac the fastest personal computer on the planet? In outright performance terms, that will be an easy no. When it comes to both multi-threaded throughput and peak single-core performance, the PC still reigns supreme.

By way of examples, two of the most popular rules of thumb for CPU performance are Geekbench 5 and Cinebench R23. In both metrics, Intel's latest and greatest desktop PC processor, the Core i9-12900K processor wallops Apple's fastest M1 Max chip. The 12900K cranks out around 1,950 points in single-core Geekbench and just under 2,000 points in single-core Cinebench. By comparison, the M1 Max is good for roughly 1,750 and 1,500 points respectively. In multi-threaded software, it's no contest at all, partly thanks to the 12900K large core-count advantage, with 16 cores to the M1 Max's 10.

What that comparison doesn't capture is the impressive IPC (instructions per clock) performance of the M1 chips. The M1 Max peaks at 3.2GHz, whereas the 12900K hits 5.2GHz. Normalize the two architectures for clock speed and the Apple processor does far more work per cycle. Of course, we've yet to see any Apple silicon implemented in a truly high-performance desktop machine.

What's more, the higher-spec M1 models combine unprecedented CPU and GPU power in a single chip and back that up with an incredibly advanced shared memory architecture delivering an epic 400GB/s of theoretical memory bandwidth. The M1 Max's GPU, in particular, obliterates any existing integrated PC graphics. With a peak performance of 10.4 teraflops, it's only slightly behind the 12.8TFLOPS of the Nvidia GeForce RTX 3060 desktop GPU and well ahead of the 7.5TFLOPS of the previous-generation RTX 2070.

The fastest comparable PC integrated graphics to the M1 Max's GPU is found in the shiny new AMD Radeon 6000 series APU, also known as Rembrandt. The fastest version of that chip tops out at 3.7TFLOPS in terms of raw GPU power. Incidentally, the integrated GPU in the new SteamDeck, also made by AMD is good for just 1.6TFLOPS. Imagine an M1 Max in the Steamdeck. In pure power consumption terms, the M1 Max may be comparable with the Steam Deck's APU. But it's so much more powerful graphically. What a thing that would be.



Where it all began: The original 1985 Apple Macintosh

Of course, the fastest desktop GPU today, which can't be had in a Mac of any kind, is the 40TFLOPS Nvidia GeForce RTX 3090 Ti. So, for now, it's the same old story. In outright performance terms, the PC rules supreme. It's also worth noting that the M1 Pro and Max chips contain additional processing blocks including a 16-core neural processing unit and video decode and encode engines.

For certain specific video production tasks, the latter engines in particular are capable of stellar performance that not many general-purpose CPUs can match.

WINNER

PC

MAC

The PC is still the performance king, the only question is for how much longer?

© APPLE

EFFICIENCY & BATTERY LIFE

If there's a single, critical metric by which Apple in the M1 age has an advantage, it's efficiency. The 10-core CPU in its most powerful M1 chip maxes out at around 40 watts of power consumption. Intel's highest performing comparable laptop processor, the Core i9-12900HK guzzles up to 115 watts. The desktop Intel Core i9-12900K can hit a scary 250 watts or more. Even the rumored quad-die monster Apple is planning for its next Mac Pro desktop machine won't get anywhere near that.

Back in laptop machines, the efficiency of Apple silicon has been a revelation. Adding the M1 to the MacBook Air while retaining the same chassis and similar all-round specifications saw battery life leap to as much as 14 hours. That's roughly a 50 percent boost compared to the outgoing Intel-powered Air. The M1 13-inch MacBook Pro is even better, notching up 16 hours or more.

The new 14-inch and 16-inch MacBook Pro models deliver similar battery life while also packing true desktop-class performance, a trick that high-performance PC laptops struggle with. Much of that is thanks to the fact that Apple silicon is based on the ARM instruction set, which is expressly architected for efficiency, while PC processors drag with them an awful lot of x86 baggage from the days before ultramobile PCs were even imagined.

WINNER
PC
MAC

There's no doubting the stunning efficiency of Apple silicon.

WINDOWS AND ANDROID GET IT ON

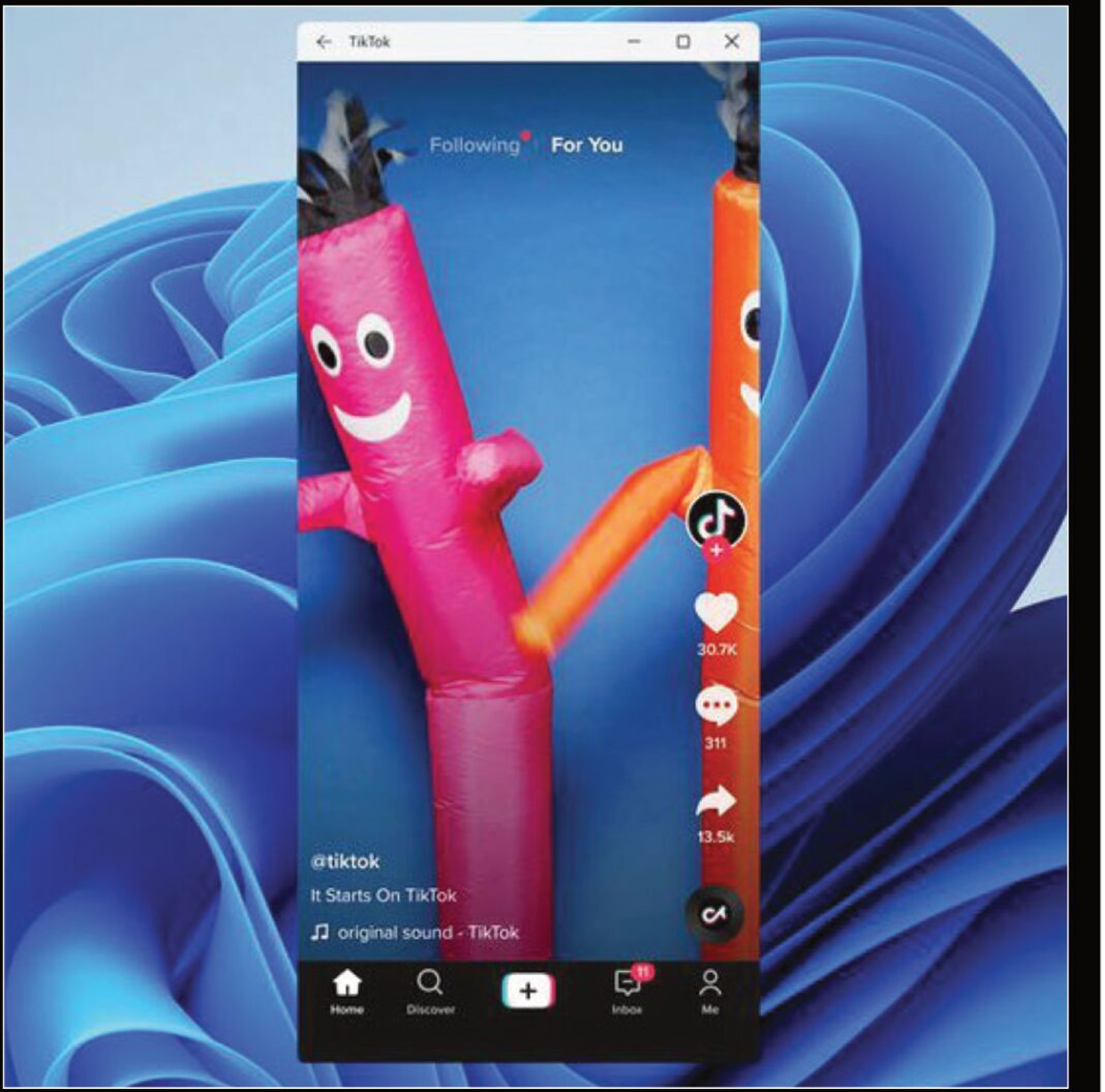
As if the software war between MacOS and Windows wasn't tough enough already, things just got a whole lot more complicated. It's all down to the increasing convergence of Macs and PCs on the one hand and smartphones on the other.

Apple's recent move to using its own silicon has allowed iPhone apps to run natively on the latest M1-powered Macs. To counter that, Microsoft has collaborated with Amazon to add the ability to run Android apps on Windows 11. Technically, it's been made possible thanks to Intel's Bridge tech, which recompiles in real-time apps made for the ARM chips in Android devices so that they can run on x86 PC processors.

Amazon comes into the equation because it's Amazon's App store being integrated into the Windows Store as the conduit for Android apps, rather than Google's Play Store. Anyway, this feature is so fresh and new, it's too early to comment on how effective and useful it will be. More or less the same can be said for iPhone apps on MacOS. It's early days.

What we will say, however, is that Apple has several obvious advantages in this area. Not only are Macs and iPhones now based on the same underlying ARM architecture, but Apple has total control over the software on its platforms.

In theory, most, if not all, modern PCs should be powerful enough to run smartphone apps, even if they require transcoding on the fly. However, the sort of attention to detail and polish that will make smartphone apps reliable and enjoyable to use on a larger computer will be more easily achieved for Apple than Microsoft.



It remains to be seen whether anyone actually wants to use TikTok on a laptop...

© MICROSOFT

GAMING

If efficiency and battery life are the Mac's killer weapons, gaming is the PC's unconquered territory. There's no reason why the Mac can't be a great gaming platform. Apple could open up support for every GPU vendor in future Macs or create its own high-performance gaming graphics. But even if that happened, a bigger problem would remain. The Mac's gaming catalog doesn't compare with the PC's and for good reason. It can cost tens or even hundreds of millions of dollars to develop a top-quality game. To have a hope of clawing that investment back, you need the largest possible customer base. And that's not the Mac.

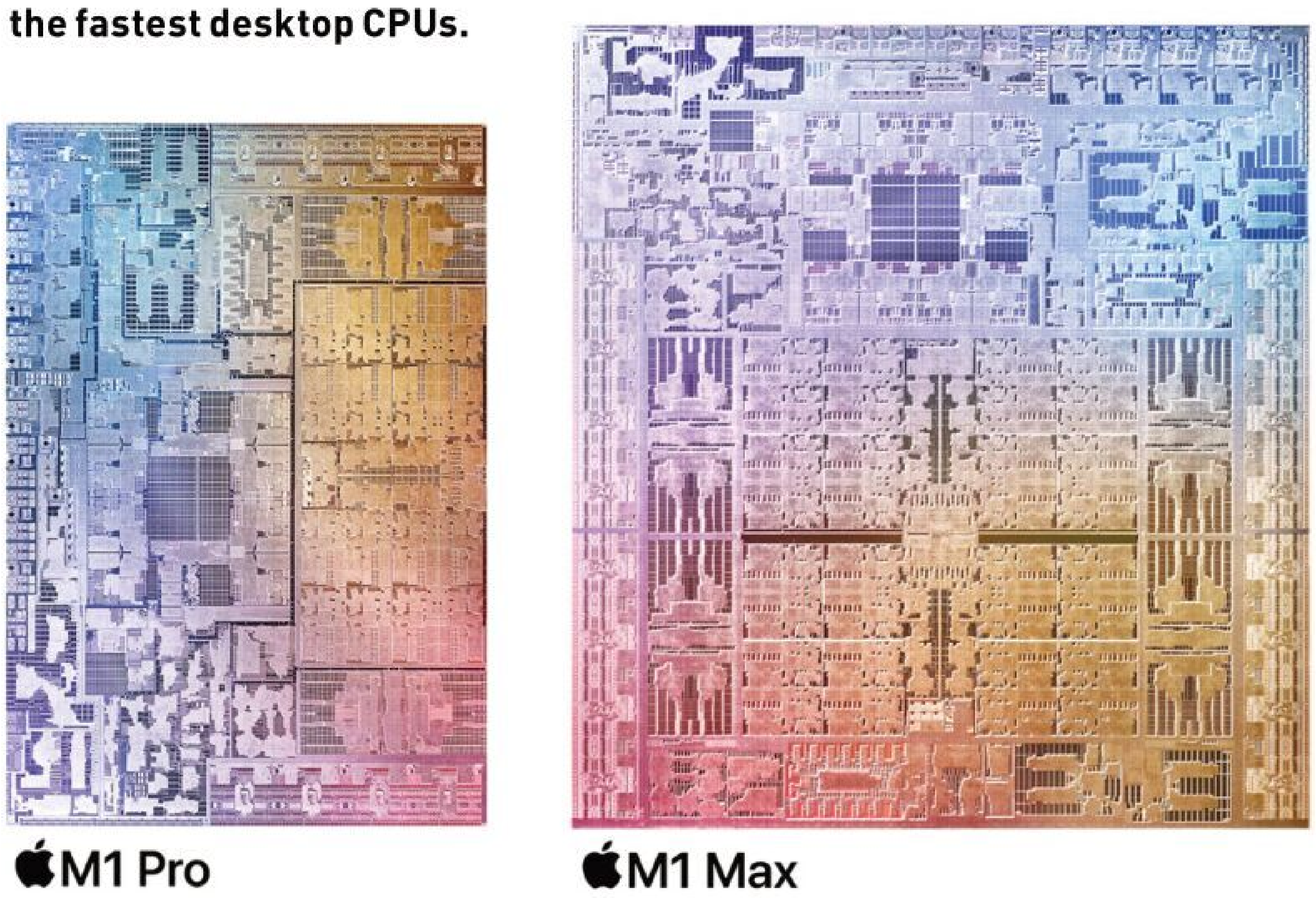
Of course, development costs can be shared across platforms. It won't cost $100 million to port a Sony PS5 or PC game to the Mac. But so few gamers use Macs, even the relatively modest cost of porting a title over to Mac isn't viable.

At least some of the explanation for that is a lack of support and enthusiasm from Apple. Arguably, it does so well from gaming on iPhones and iPads, it scarcely needs to worry about gaming on the Mac. But whatever the reason, the overall conclusion is the same. If you're even remotely serious about gaming, you want a PC, not a Mac.

WINNER
PC
MAC

It's absolutely no contest.

The Apple M1 Max is an incredible mobile chip, but it has a tougher time competing with the fastest desktop CPUs.



SECURITY & STABILITY

WINNER
PC
MAC

Partly by design, partly due to circumstance, Macs are safer and more stable.

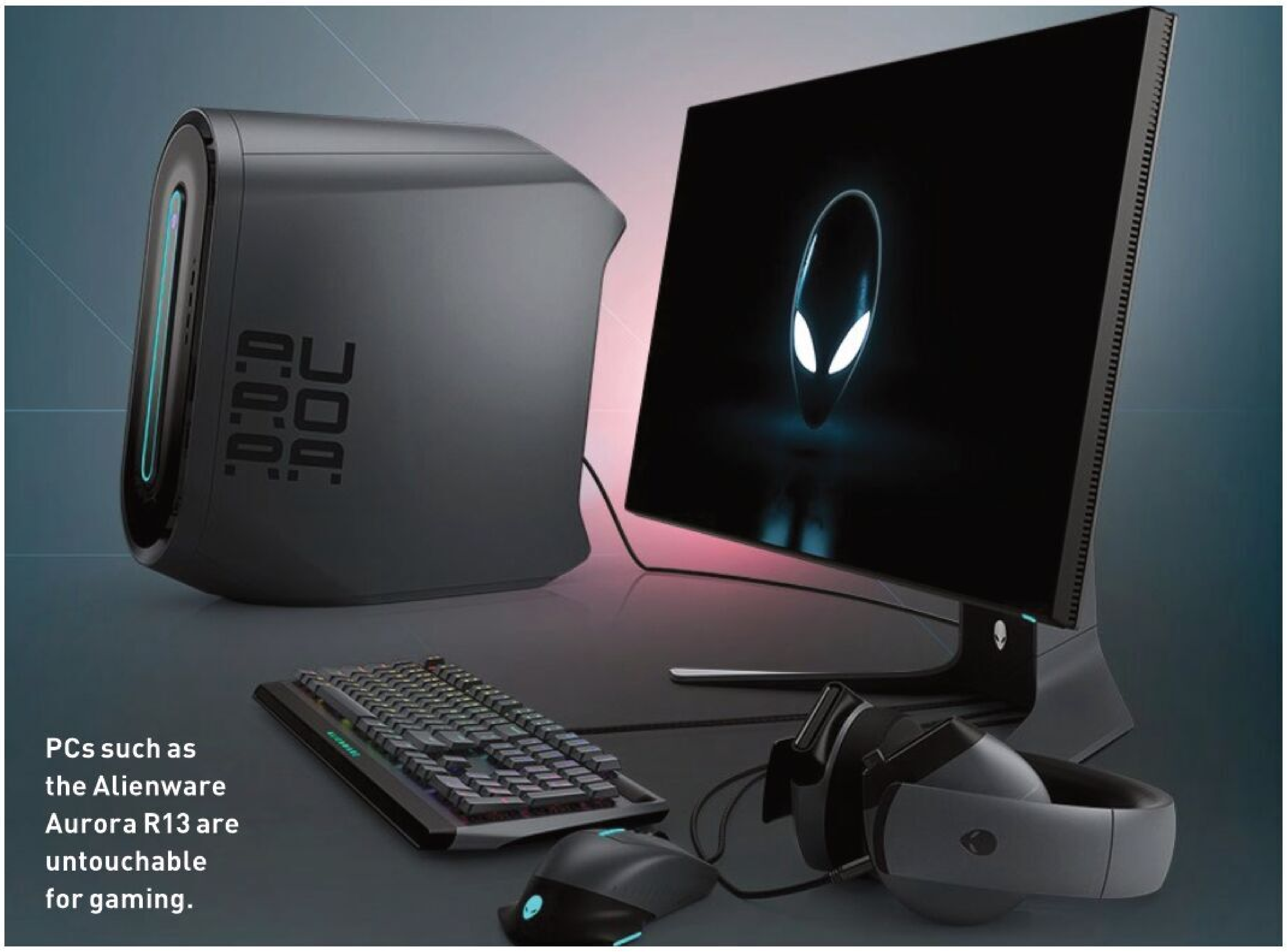
For the most part, this comparison is a no-brainer. By simple dint of being less popular than PCs, Macs have always been less of a target for bad guys creating malware and other exploits.

However, it's also true that Apple has better control over the whole hardware and software stack, thanks to combining the two in a limited number of in-house configurations. So, Macs are generally cleaner and tighter when it comes to vulnerabilities, even before the question of popularity.

To give credit where it's due, Microsoft is far more proactive with security than it used to be, having introduced features including Windows Defender updates and anti-ransomware measures. Equally, Macs are far from invulnerable to viruses, spyware, botnets, and the like. Both Macs and PCs are available with fingerprint sign-in, while PCs also support the Windows Hello suite of biometrics including facial recognition and iris scanning, albeit the latter is rarely implemented. Likewise, both operating systems offer built-in VPN support, so that isn't much of a differentiator.

As for stability, that tighter Apple control over software and hardware configurations really pays dividends here. Optimizing the almost infinite array of PC hardware for stability is a task that's orders of magnitude more difficult than ironing out the bugs from a handful of retail Mac systems. Even Microsoft's own Surface PCs are more prone to hanging than Macs.

Of course, when it comes to both reliability and security, PC users have the option of running Linux as an alternative operating system. But that makes for a totally different proposition that's arguably separate from the classic PC versus Mac comparison.



PCs such as the Alienware Aurora R13 are untouchable for gaming.

© DELL, ALIENWARE, APPLE

In the end, what the comparison boils down to is that the PC is so much more flexible and powerful.

OVERALL

Listen, of course, we love the PC. We have the word "PC" in our title. But we have absolutely no problem recognizing that our favorite platform might not always be the best option in every circumstance.

Right now, a strong argument can be made for the MacBook Air M1 being the best sensible money laptop computer for daily driving duties, including browsing the web and consuming video or music content. It's incredibly well built, it's slick and responsive to use, thanks to both MacOS and the new M1 chip, and it offers features such as a fantastic battery life, a great screen, and by far the best speakers of any comparable portable.

Provided you don't want or need touchscreen support and that you're not using apps only available on Windows, the M1 Air is a fantastic, unpretentious and effective machine. In fact, the M1 Air is a great example of how good the Mac can be when all of Apple's advantages come together, when its ability to control every aspect of the machine, from hardware to software, is fully exploited. But that doesn't necessarily make Mac better than PC, overall.

Whether it's Intel once again flexing its muscles with the punchy new Alder Lake CPU or the fact that you can't have a touchscreen Mac because Apple has decided it knows better than you, in the end, the PC is just so much more flexible and powerful than the Mac.

For the sheer breadth of software and hardware choices the finely grained control that Windows gives advanced users over every aspect of their PC, or the PC's status as comfortably the most powerful and capable gaming platform on the planet, it's ultimately no contest when it comes to an overall platform comparison.

WINNER

PC

MAC

There can be only one. And it's the PC.

THE TOMORROW WAR

In terms of pure, outright performance, the PC rules supreme. After all, the current Mac Pro is based on relatively ancient Intel CPUs and Intel's latest Alder Lake CPUs for laptop PCs just have the edge on the Apple M1 Max for both single and multi-threaded CPU performance.

As we've also said, while the M1 Max has incredibly impressive graphics performance for an all-in-one chip, it can't compare with the best dedicated GPUs, most of which aren't available on any Mac.

But how long will all this remain the case? Rumor has it that Apple is preparing a new megachip for its upcoming Mac Pro containing no fewer than four M1 Max dies. In CPU terms, that would mean 40 cores, 32 of which would be high performance.

You'd need an awful lot of Xeon hardware to compete with that. Very likely, no existing consumer-class Intel Core-based PC would be able to keep up.

On paper, a quad-die M1 Max would also roughly be on-par with the mighty Nvidia GeForce 3090 Ti for GPU power and totally obliterate any PC processor for CPU performance. Problem is, of course, the PC isn't sitting still, either.

Both AMD and Nvidia are working on new families of graphics chips, due out later this year, that are expected to deliver at least twice the rendering power of a 3090 Ti, enough to thoroughly spank even a quad-die M1 Max.

Meanwhile, AMD and Intel have aggressive CPU roadmaps for the next 18 months. Intel's Raptor Lake chips are due out later this year and promise a roughly 15 per cent single-core boost, plus as much as 40 per cent more multi-threaded performance over the 12900K chip and its Alder Lake siblings. Less than a year after Raptor Lake, Meteor Lake will raise the bar once again.

The second half of 2022 will also see AMD's new Zen 4-based Ryzen 7000 Series CPUs arrive and with them single and multi-core performance boosts of 25 per cent and 40 per cent respectively compared to AMD's existing Ryzen 5000 Series chips. AMD is expected to keep on trucking in 2023 with Zen 5 and another big step in performance.

All of which makes it hard to predict which platform will maintain performance leadership over the next few years.

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HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

TIP OF THE MONTH

ACCOUNTKILLER
Instagram
for this guide and more visit
accountkiller.com

ACCOUNT KILLER

Social media getting you down? Feel like chucking in the towel? Sometimes simply logging out of an account isn't enough and the time has come to completely part ways. If you want to delete an account for good, go to www.accountkiller.com and type into the search bar the website where you have an account. Scroll down, follow all the steps and you should be able to fully kill it once and for all. Take that, Facebook!

MAKE – USE – CREATE

60
The SAM Coupé, a veritable cult classic machine

62
Start AI-powered image editing with Luminar Neo

66
Frankenbuild! Raiding the stock room for parts

© ACCOUNTKILLER.COM, WIKIMEDIA, LUMINAR-NEO

SAM LEWIS
STAFF WRITER

LATE TO THE PARTY

This month, I decided to try out Xbox PC Game Pass—it's essentially the Netflix formula for games—and have been downloading games left, right, and center. The only downside is that my SSD is getting close to its capacity. I'd already purchased *Forza Horizon 5*, which is available on Game Pass, so I could have saved a few bucks there, but with access to tons of other games, it's easily worth $10 a month. Looking back, it's strange that I hadn't tried it out before, as I spend that much on games anyway, and this way, I get to try titles I wouldn't necessarily have bought.

On another note, I've ordered an Amazon Echo Auto for my partner's car. She recently changed motors and the infotainment on the new one isn't up to scratch. Hopefully, having Alexa should allow her to play music wirelessly, and make phone calls hands-free in the car. Before researching it, I was unaware of the Echo Auto, but it's a screenless and speakerless Amazon Echo device. Plug it into the auxiliary port and the car's 12V outlet, connect it to your phone, and it essentially lets your car play music wirelessly, make calls, and most importantly add snacks to your Amazon shopping list. It's still in the post, so I'll let you know how it works in the next issue.

↘ submit your How To project idea to: editor@maximumpc.com

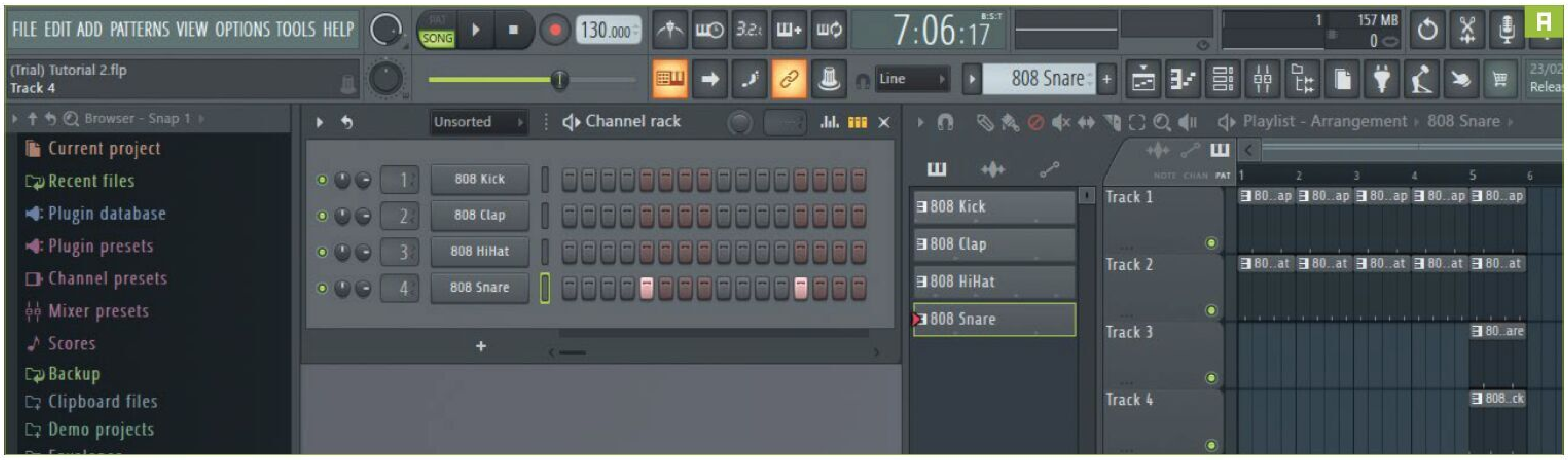
The key stage: Add notes in FL Studio 20

YOU'LL NEED THIS

FL STUDIO 20
www.image-line.com

LAST ISSUE, we focused on one of the most important parts of creating an audio production—the drumbeat. The beat is the foundation to any song, and while you don't have to use drums as any instrument can make a beat, drums are as good a place as an to start on FL Studio. If you haven't done so already, check out our previous tutorial before you try this one out.

This month, we'll be turning our attention to creating some notes in a track using the piano roll. Before you start panicking, you don't need to be familiar with all of Mozart's work in order to achieve this. Even the folks here at *Maximum PC* can put something together with rhythm and we have pretty much zero musical talent. We're going to take what we learned last time and add to it so that eventually you'll be able to produce your own tracks. The first thing to remember is that all tracks consist of layering, and that's what we're doing here. We'll be adding musical notes to a beat to create a simple track with a melody. **–SAM LEWIS**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Track 4
Line
808 Snare
Browser - Snap 1
Current project
Recent files
Plugin database
Plugin presets
Channel presets
Mixer presets
Scores
Backup
Clipboard files
Demo projects
Unsorted
Channel rack
808 Kick
808 Clap
808 HiHat
808 Snare
Playlist - Arrangement › 808 Snare
Track 1
Track 2
Track 3
Track 4

1 FEEL THE BEAT

To kick things off, we're going to create a simple drumbeat pattern using the channel rack. Open FL Studio into a new workspace, and choose around four different instruments to use together to create this beat. We've chosen an 808 kick, 808 clap, 808 hi-hat, and an 808 snare. It's ideal to use these types of drums, as it gives you both highs and lows to combine for an interesting pattern [**Image A**].

» To listen through your track so far, remember to select the 'pat' button at the top of the screen to hear your pattern. When listening to the playlist window (the whole track together), remember to switch it back to the song option.

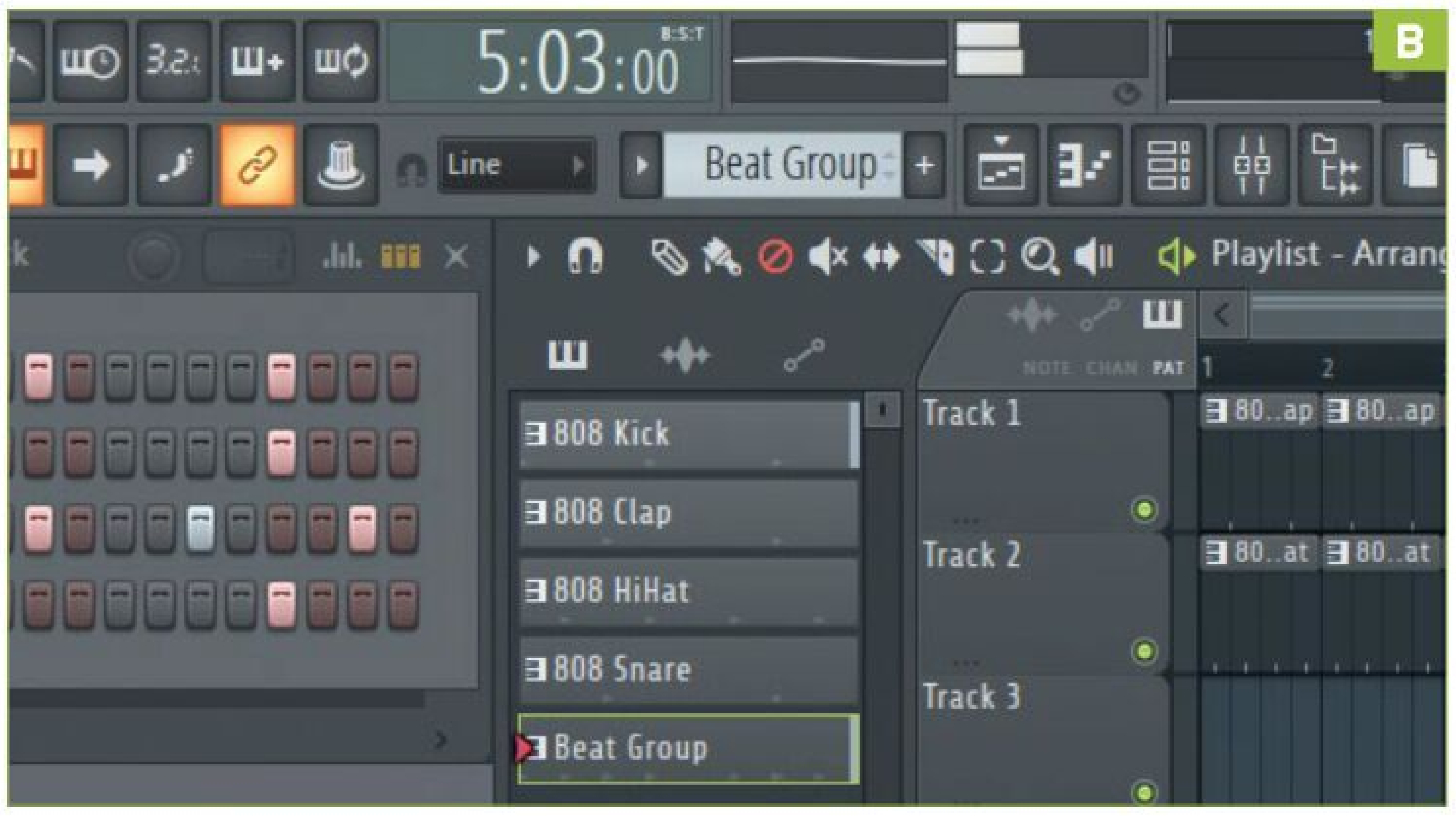
» Once you've played around with these drum beats and have a pattern you're happy with, you can start by drawing it into the playlist. We also copied this pattern and called it 'beat group'. With the original pattern, we split this up into its individual components to build up the song. To do this, right-click on the pattern and select 'Split by channel'. This will then break the track down into its separate components.

2 HI-HATS OFF

To add to our song, we start by introducing the 808 clap and 808 hi-hat together. These higher pitched beats are building up in a pattern of four before we add in the bass drums.

» At the start of the second loop of four, we add in our 808 kick and 808 snare drum. This gives us added depth to our simple beat and gives it a fuller sound. Make sure you have the correct pattern selected and use the draw icon—it looks like a pencil and sits above the playlist window [**Image B**]. Then simply click and draw into the playlist window to add your sounds. Once you've built up your song with a few drums, you can add a melody. Our beat isn't revolutionary by any means, and it certainly won't be troubling the Billboard Top 100 anytime soon, but it will give you an idea of how to layer a track.

» With our drums sorted, these will play in the background while the melodies come in and take center stage. To create these, we need to choose some piano or synth keys that pair well with the 808 drums. Feel free to use whatever sound packs you like, as the more you experiment with different instruments the more you will get used to constructing a basic song in FL Studio.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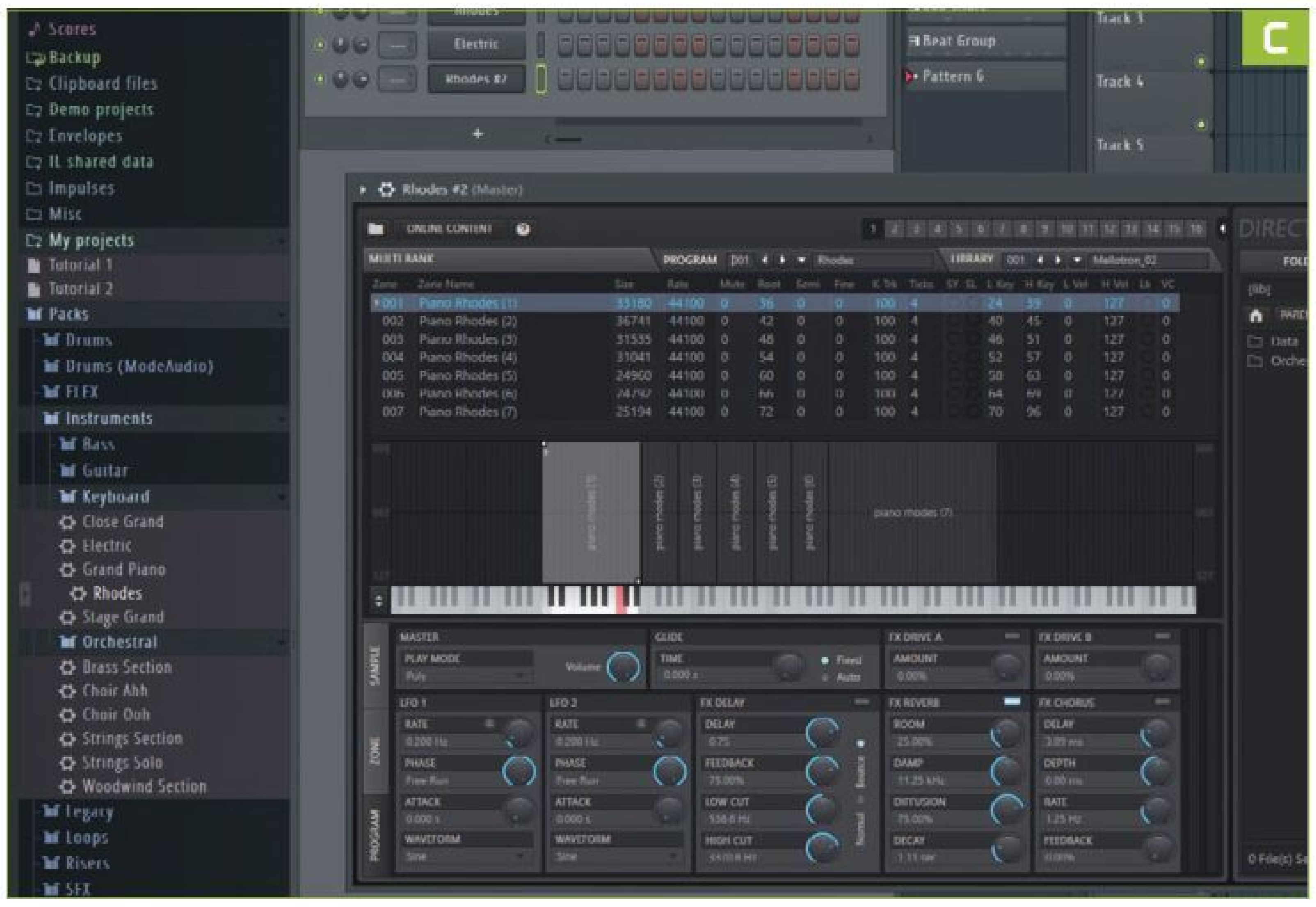
5:03:00
Line
Beat Group
Playlist - Arrang
808 Kick
808 Clap
808 HiHat
808 Snare
Beat Group
Track 1
Track 2
Track 3


C
Rhodes #2 (Master)
Scores
Backup
Clipboard files
Demo projects
Envelopes
IL shared data
Impulses
Misc
My projects
Packs
Drums
Instruments
Keyboard
Close Grand
Electric
Grand Piano
Rhodes
Stage Grand
Orchestral
Brass Section
Choir Ahh
Choir Ooh
Strings Section
Strings Solo
Woodwind Section
Legacy
Loops
Risers
SFX

3 GOING BY THE BOARD

Head to the left side of the screen to the packs. Under instruments, we chose Rhodes under the keyboard section. To preview the sounds, drag a style underneath the channel rack and it opens a similar window to the one in the image [**Image C**]. You can preview this by clicking on the keys. Create a new pattern and name it appropriately to whatever instrument you're choosing—we named our pattern 'keys'.

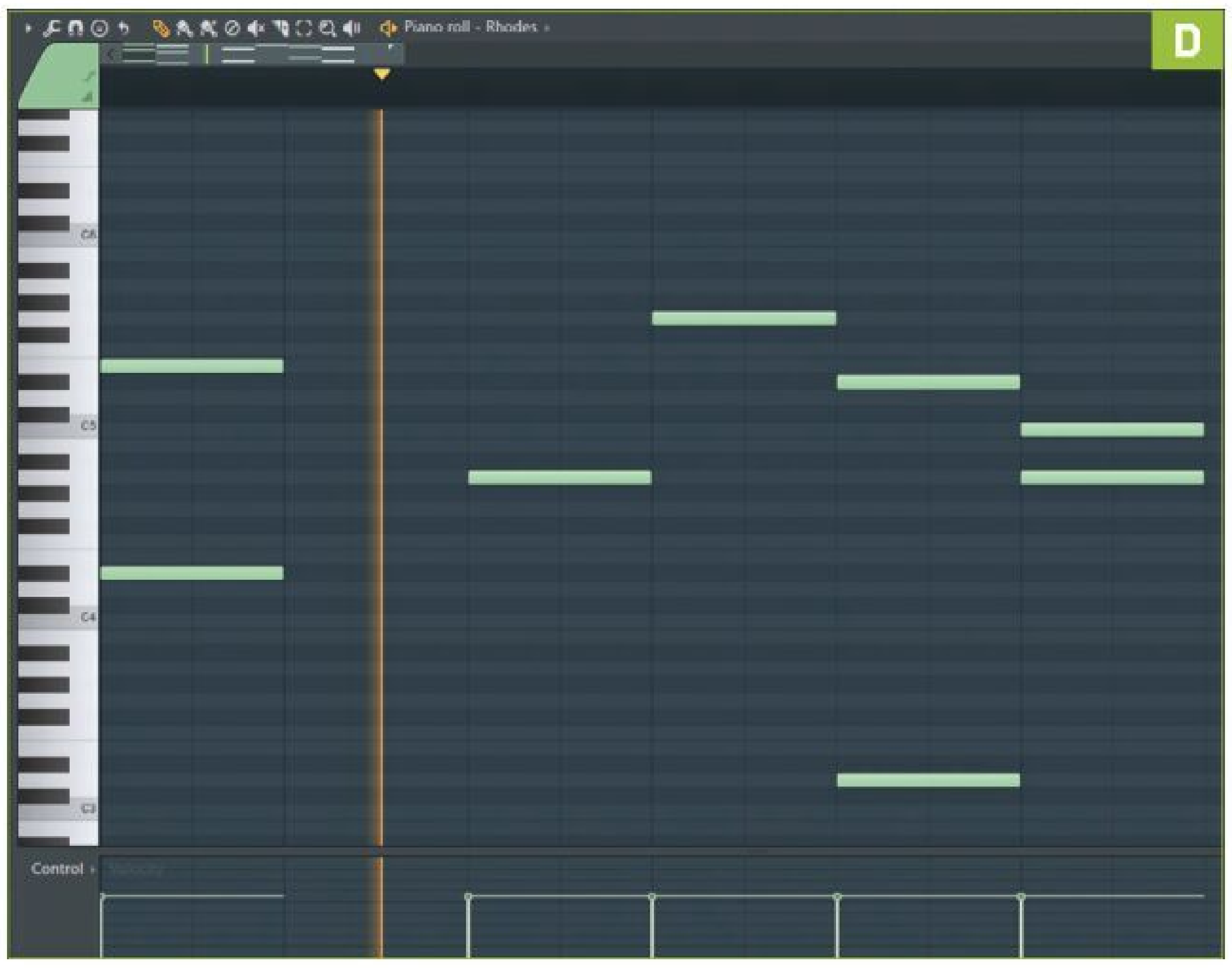
›› After this, you need to open up the piano roll, which will give you a virtual keyboard that you can draw on to create a new pattern. It's similar to how the playlist window works and to add sounds, use the pencil icon again and right-click on a block to remove it. Once you've drawn your pattern, you'll see it in the channel rack like the other instruments in the track. If you play the pattern, you can listen and edit live on the piano roll to hear what the melodies sound like with your background beat.

4 READY TO ROLL

After some time playing around with the piano roll, hopefully you'll have a pattern that you're happy with. Ours sounds more like something from a retro video game than a modern song, but that was a happy accident. Sometimes trial and error can work wonders [**Image D**].

›› Now we need to add it to our playlist. Make sure the correct pattern is selected and draw in your new pattern where appropriate. We added it after four bars of our drumbeat and also continued our drumbeat alongside this piano pattern. With just two types of instruments, a drumbeat and a basic piano pattern, we've created a retro gaming riff.

›› These tutorials are more to demonstrate how to piece things together. But with a little practice, you could create a jingle and eventually a full track. If you're feeling braver than us, you could even add your own vocals to the mix [**Image E**]. Anyway, we hope you enjoyed the tutorial and have fun with FL Studio 20. ⏻


D
Piano roll - Rhodes
Control

FL STUDIO SOUNDS

Sounds
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SAVE $200 90% OFF
SPECIAL OFFER
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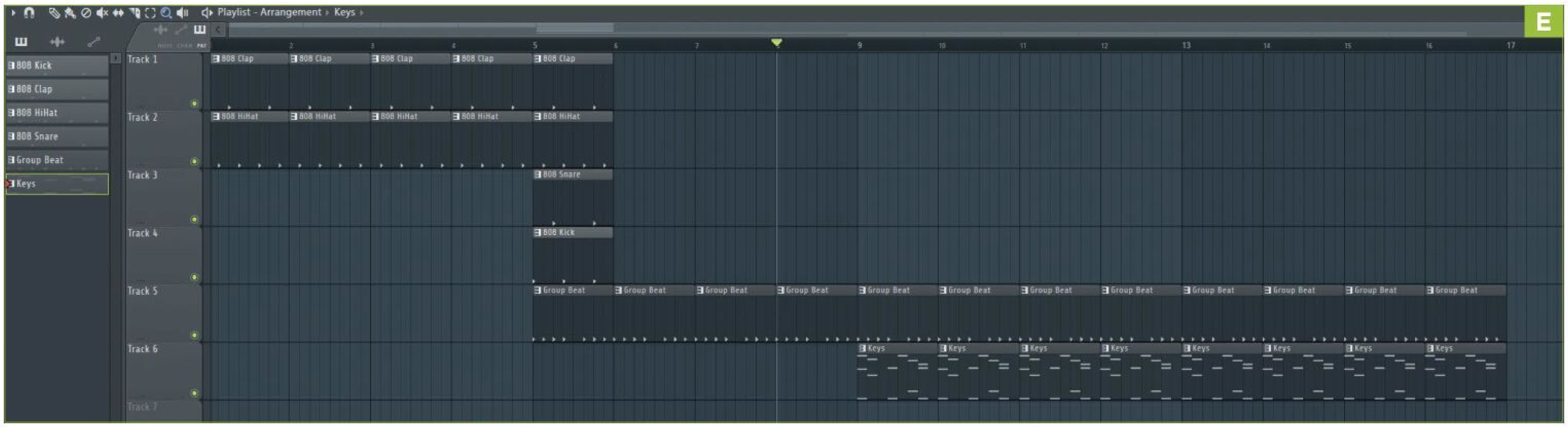
90% OFF SAVE $179
GENRE
Loops
Samples
Clear all
FL STUDIO CHART
1 The Trap Bundle
2 The Hip Hop Bundle

If you want to add some more sounds to Fruity Loops, a great place to start is the official website [www.image-line.com]. This store has plenty of loops and sample packs to check out. Implementing these into your tracks not only allows you to make many different songs, but can also add depth to your beats. The majority are paid for, but they start at relatively small amounts but go up to large packs with lots of sounds.

You can also preview these sample packs and loops on the website to get a feel for which ones best suit your style, or simply to get some inspiration. Along the top, you can choose a genre, select whether you'd like to find loops or samples, search, and also sort the page. The layout is vibrant and clear, making it easy to browse through the site and find the perfect sounds for your tracks.


E
Playlist - Arrangement › Keys
808 Kick
808 Clap
808 HiHat
808 Snare
Group Beat
Keys
Track 1
Track 2
Track 3
Track 4
Track 5
Track 6
Track 7
808 Clap
808 HiHat
808 Snare
808 Kick
Group Beat
Keys

© FL STUDIO 20

Machine of the Month: SAM Coupé (1989)

YOU'LL NEED THIS

A COPY OF SIMCOUPE
Windows and Linux are both supported. Extra BIOS files aren't needed.
http://www.simcoupe.org

IF YOU'RE A FAN of obscure computing gems, you're in for a treat this month. With sales figures only numbering in the thousands, the SAM Coupé is a true rarity and any working collection will cost a king's ransom.

However, this hasn't stopped it from becoming a darling of the cult computing scene. The SAM Coupé sits in a strange gap between the 8-bit and 16-bit worlds, and uses some unusual hardware. The odd experience it provides has earned it many modern fans, and enthusiastic hobbyists are still developing new software and expansions for the machine. **–JOHN KNIGHT**

1 DEVELOPMENT AND LAUNCH

The Coupé was developed by Miles Gordon Technology (MGT), a Welsh manufacturer that had already made a name for itself developing quality storage drives for the Sinclair ZX Spectrum. The Spectrum was growing old and its adoptive owners, Amstrad, had no intention of developing the system.

›› But MGT had a proposition: by using the newer (but rare) Zilog Z80B processor, their machine could theoretically deliver around twice the performance, bringing Spectrum owners into the next decade, while still being able to run the existing library.

›› The SAM Coupé launched in December 1989, at a base-spec price of £170. The Z80B processor was clocked at 6MHz with 256KB of RAM, and up to two removable 780KB 3.5-inch floppy drives, available at £90 each.

›› Graphically, the Coupé could display old Spectrum video modes, but otherwise had a maximum resolution of 512 x 192, with 128 colors available in lower resolutions.

›› Sound-wise, the Coupé really shines, with MIDI ports as standard and the same Philips SAA1099 sound chip used by Creative Labs' original Sound Blaster providing six stereo voices across eight octaves.

2 SOFTWARE

In short, Coupé software feels almost 16-bit. Although the Coupé uses an 8-bit processor, its performance is closer to early 16-bit computers. However, the Coupé lacked hardware-assisted scrolling or sprites, and having the CPU and display share RAM resulted in a speed penalty.

›› Nevertheless, many titles were able to work around these limitations. *Defender* (1998) faithfully recreates the original arcade experience, running at a smooth 50fps, and *The Adventures of Captain Comic* (1990) knocks the socks off the original PC release.

›› Arcade platformer *Defenders of the Earth* (1990) was the first major release for the system. The two biggest titles were *Lemmings* (1993) and *Prince of Persia* (1990), both of which are respectable. Other big names include an update to *Manic Miner* (1992) and *Escape From the Planet of the Robot Monsters* (1991).

›› The Coupé has a number of quality multimedia applications. Each Coupé shipped with *Flash!* (1989), a snazzy graphics package by ace Swedish programmer Bo Jangeborg. Musicians should check out *Sound Machine* (1991), *E-Tracker* (1992), and *SAM MOD Player* (1996), which can play Amiga sound files.

›› As for the modern homebrew scene, *Battle Zone* (2021) is an impressive port, *Pang* (2013) wouldn't feel out of place on a Sega Genesis, *Rick Dangerous* (2021) is another great port, and there is a sizeable collection of public domain demos.

3 SO WHAT WENT WRONG?

Initially, enthusiasm was high. The Coupé provided a logical upgrade: it was backward-compatible with the classic 48K ZX Spectrum; tape loading was twice as fast; and the machine had near 16-bit performance levels but at a much lower price.

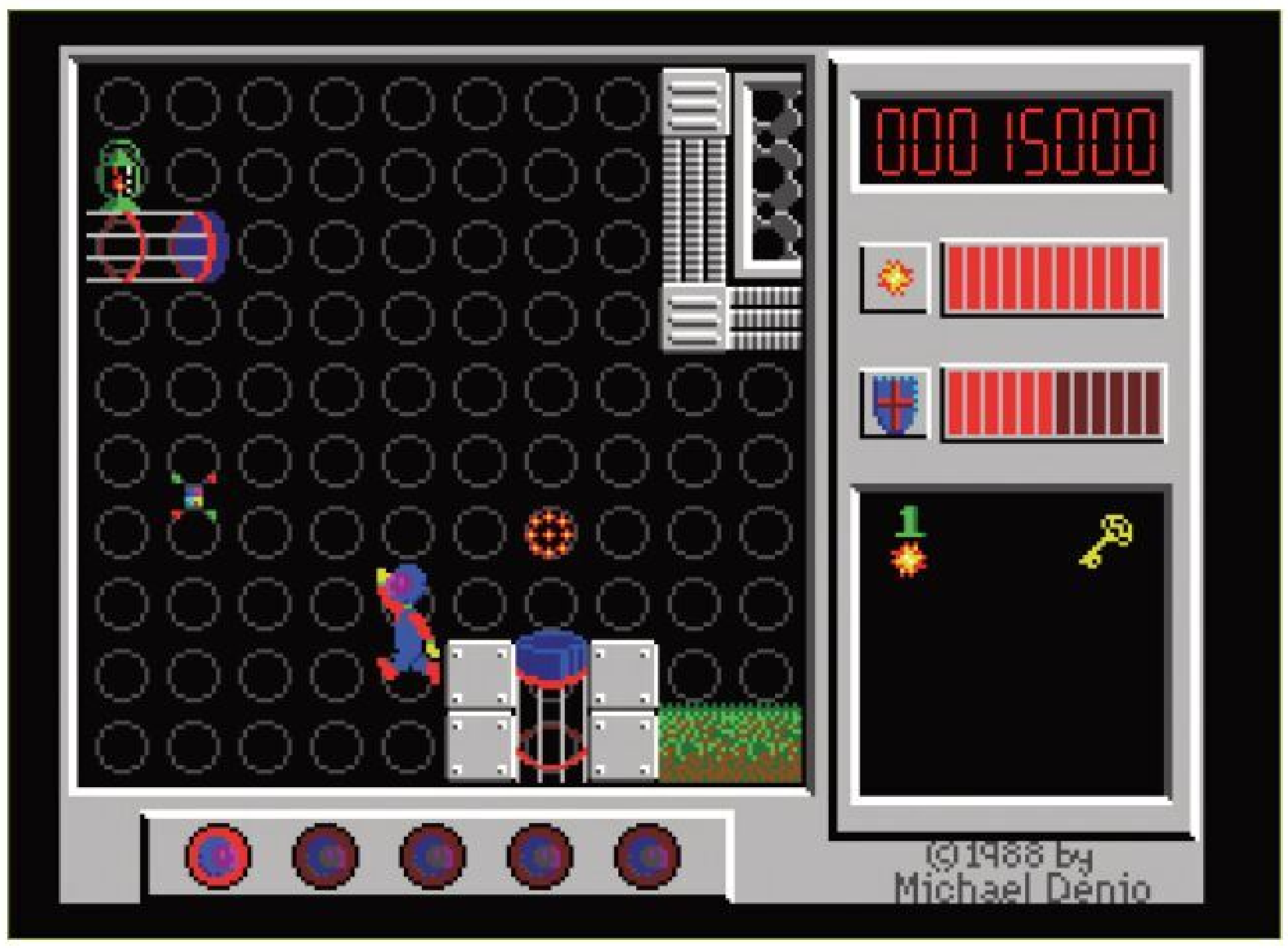
›› Software houses were expecting to be able to do quick game ports, combining Spectrum code with Atari ST graphical assets, and Sinclair magazines had dedicated SAM Coupé sections. But this dried up when a bodged launch meant it arrived late to market.

›› Numerous production issues meant only a small number were delivered before Christmas. Those who did get machines didn't receive floppy drives for several months. Worse still, Spectrum owners found their software was only partially compatible.

›› Prices for 16-bit machines were dropping steadily, which was more bad news for the Coupé. Although the base unit's launch price was attractive, if the customer added more RAM and a disk drive, this brought the machine's price nearer to that of the Atari ST.

›› After some warranty issues, including thousands of buggy ROM chips, MGT went bankrupt in June 1990. However, Miles and Gordon still had faith in their product, and with their own finances started a new company, SAM Computers, plus a software label, Revelation.

›› SAM customers finally started getting the kind of software they wanted, and Coupé prices dropped to £200 for a machine with a single disk drive.



›› *Captain Comic* (1990) is impressive and crushes the PC version thanks to a MIDI soundtrack and voice samples.

© MICHAEL DENIO

MGT
SAM coupé

›› **Spectrum owners would have been deeply envious of the quality full-travel keyboard, chic styling, and removable disk drives.**

›› Nevertheless, this wasn't enough to fight off established rivals, and SAM Computers was liquidated in July 1992. West Coast Computer acquired the remaining stock and began selling an updated 512KB model in 1993. These models were sold in various forms until 1999, when West Coast also shut down.

›› Overall, only around 12,000 units were sold, though an active homebrew scene has continued to this day.

4 EMULATION

The best choice of emulator is SimCoupe, by Simon Owen. It has software builds for Windows, Linux, and MacOS, plus older builds for obscure platforms.

›› Windows users are given a handy executable installer. Simply download and run the .exe file, and follow the prompts.

›› Linux users are given a 64-bit .deb file, though an older non-distro-specific binary tarball is available, plus the option to compile from source code.

›› If you have installed the official .deb file, you can launch SimCoupe with the command:

```
$ simcoupe
```

5 USAGE

The Windows and Linux versions have different interfaces. The Windows version has a modern interface, whereas the Linux version is driven by the keyboard and feels almost retro in itself. Shortcut keys are the same across both versions.

›› As noted by the welcome screen on first boot, the most useful key bindings are:

- **F1: Insert disk image**
- **F10: Options**
- **F12: Reset**
- **Ctrl-F12: Exit emulator**
- **Numpad-9: Boot drive 1**

›› In addition to these bindings, we would also point out that F2 loads a disk image for Floppy Drive 2 and F8 toggles full-screen.

›› Before you get started, it's worth browsing the Options screen, under Tools → Options in Windows, or by pressing F10. The Input section has the option 'Enable SAM mouse interface', which will be essential for programs like *Flash!* or *Lemmings*.

6 LOADING DISKS

To load disk images, open the browser for Disk Drive 1 by pressing F1, or optionally for Windows users, choosing File → Open from the main menu. Open your disk file and your disk should boot automatically.

›› Reboot your system with F12 before loading new disks. If you're stuck on the SAM boot screen, try pressing 9 on the number pad.

›› While most disks should boot automatically, plenty of hobbyists' disks won't. We can't show you how to start all programs, but this is the most common scenario.

›› If you get an error message about 'no AUTO* file', press Enter and you will get a white cursor. Assuming you're using Floppy Drive 1, enter:

```
dir 1
```

›› A file list will appear with a list of file numbers on the left. Look for anything marked 'BASIC', or any other obvious loadable programs in the file list, and take note of its file number. Now enter the load command with your file number (19 in this example), like so:

```
load 19
```

›› If it doesn't launch after this command, enter:

```
run
```

›› For further troubleshooting, see the excellent manual available on the project's website. ⏻

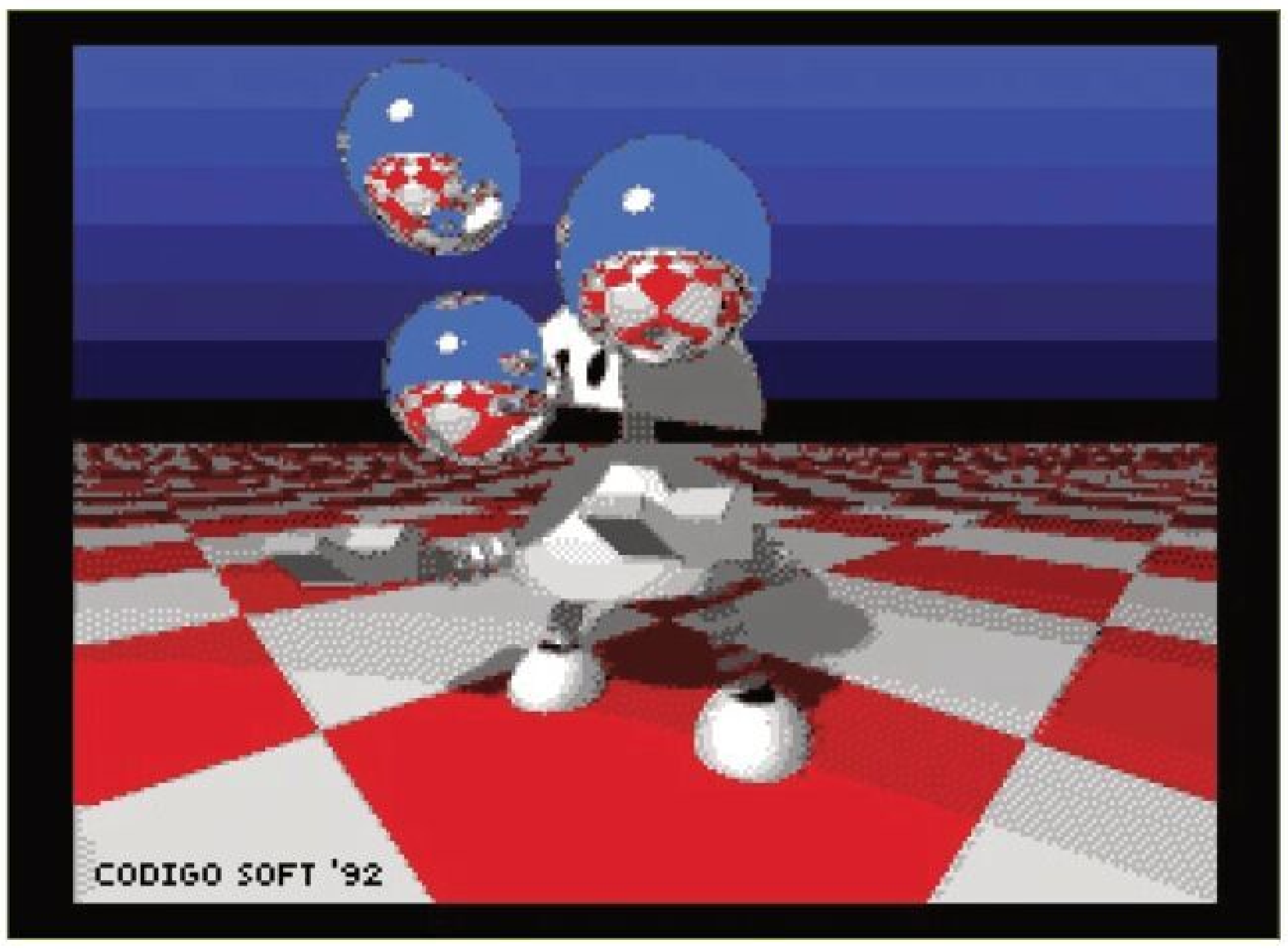
FINDING SOFTWARE

As usual, archive.org has a couple of good software collections, plus reading materials, and the site can worry about its own copyright problems. For something on a better legal footing, www.worldofsam.org has taken the time to catalog the Coupé's software archive. It only links to software that it has approval to redistribute.

SPECIFICATIONS

SAM Coupé (1989)

CPU:	Zilog Z80B @ 6MHz
RAM:	256KB/512KB (4.5MB maximum)
Graphics:	V512 x 192 maximum resolution, 128 maximum colors
Sound:	Philips SAA1099
Storage:	3.5-inch 780KB floppy, cassette
OS:	SAM BASIC, CP/M via software
Launch Price:	$230
Released:	December 1989
Production:	1989-1992, 1999
Worldwide sales:	12,000



›› **The Coupé had a demo scene similar to Commodore's. Here is the Amiga Juggler demo with SAM, the robot mascot.**

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AI-powered Image Editing

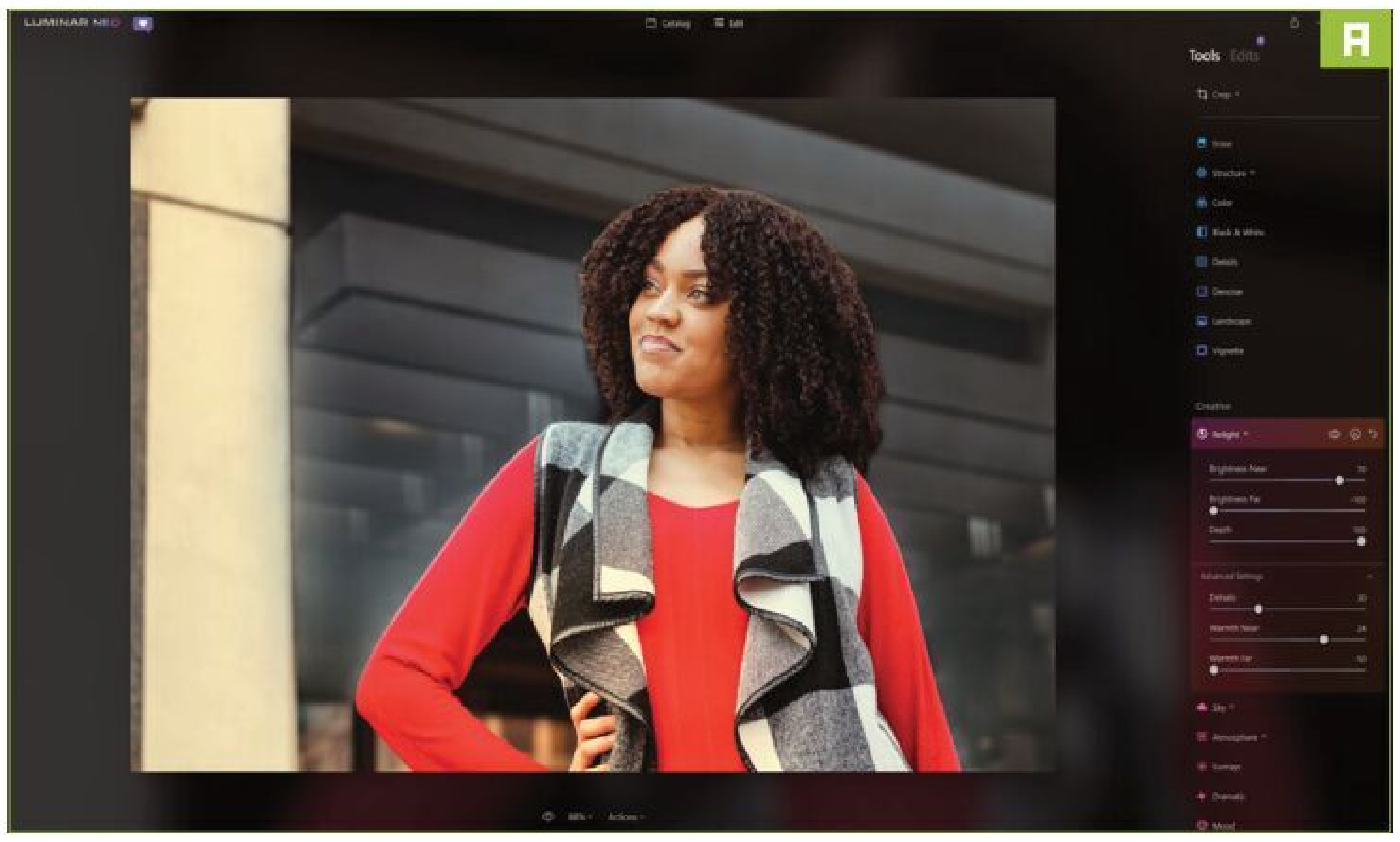
YOU'LL NEED THIS

LUMINAR NEO (OUT LATE 2022)
https://skylum.com/
Images to edit

LUMINAR IS AN IMAGE EDITING APP that we've covered before through a couple of previous incarnations and now the time has come for another new version. Luminar Neo is the latest edition, due for release later in 2022, but *Maximum PC* has managed to get hold of a special pre-release version to show you the kinds of things its AI-powered tools are capable of.

Neo brings together features from the previous Luminar 4 and Luminar AI releases and adds some new stuff of its own. Since its launch in 2016 as a Mac-only app, Luminar has gained features and Windows compatibility, concentrating on effects that can be achieved with sliders and automatic selections rather than requiring a great deal of manual input. Its last big innovation was sky replacement, which automatically selected the area of sky in an image and replaced it with a new sky from a cache of sample photos, or from one you've taken yourself. Then there were the giraffes—indeed, the ability to add tall African herbivores to an image turned out to be the sort of tool many photo manipulators didn't know they wanted.

There's more of that sort of thing than ever before in Luminar Neo, which is turning out to be an intelligent rethink of what makes the app unique. **–IAN EVENDEN**



1 RELIGHT

Once you've got an image open, it's time to see what the app can do. One of our favorite features is Relight, an AI tool that splits your image into near and far layers and allows you to alter the brightness of each individually. It helps if you give it a photo that plays to its strengths—perhaps one in which your subject is standing between clear foreground and background objects—and use the Depth slider to set the point at which they're fully diverged [**Image A**]. Then you can play with the Brightness Near and Brightness Far sliders, to see what effects they will add.

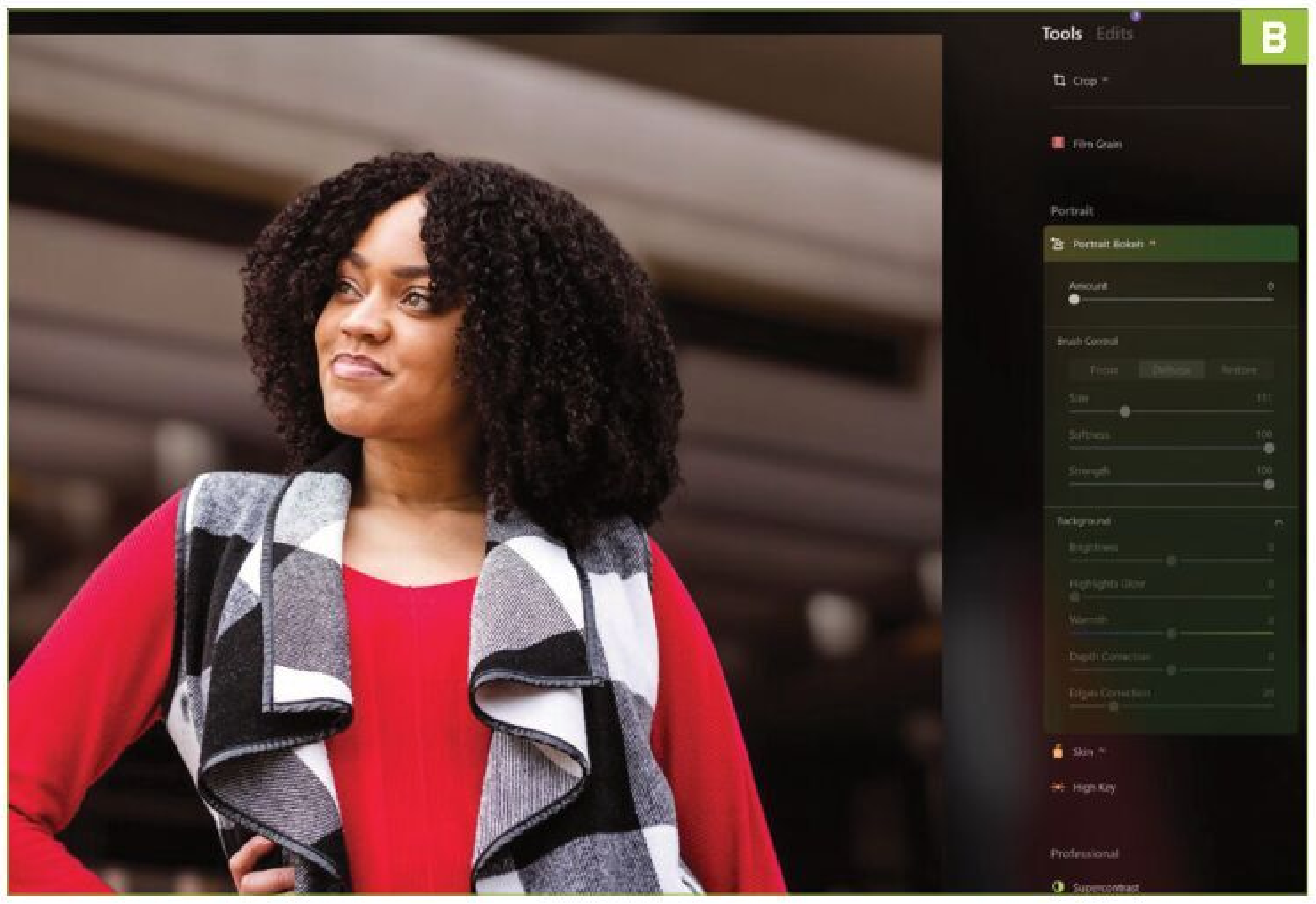
2 PORTRAIT BOKEH

Forgotten your f/1.4 lens? No matter. Luminar Neo can identify the subject in your picture and blur the background away in just a couple of clicks. Open the image you want to work on, then scroll down to Portrait Bokeh AI, which is on the right below Relight in the Portrait section. To set it in action, just move the Amount slider to the right. Drop down the Brush Control section to adjust the mask that's been automatically produced for the effect if it's blurring bits that shouldn't be blurred, or leaving the wrong parts of the image sharp. We find that as long as there's a strong subject to the photo and not too much in the way of leafy branches or curly hair to confuse it, the AI engine does a good job [**Image B**]. Thankfully, the Focus, Defocus, and Restore brushes offer a chance to fix any mistakes.

›› Below that are Background options. These control the quality of the background blur you're creating and cover its brightness compared to the subject, the glow of any highlights in it (don't expect the kind of bokeh balls you'd get from a real fast lens), and the white balance ('warmth'). There's also the ability to change the depth that the AI has perceived and mapped in the image, defining more clearly what the background is if needed, and the edge of the mask can be expanded or contracted too, with Edges Correction.

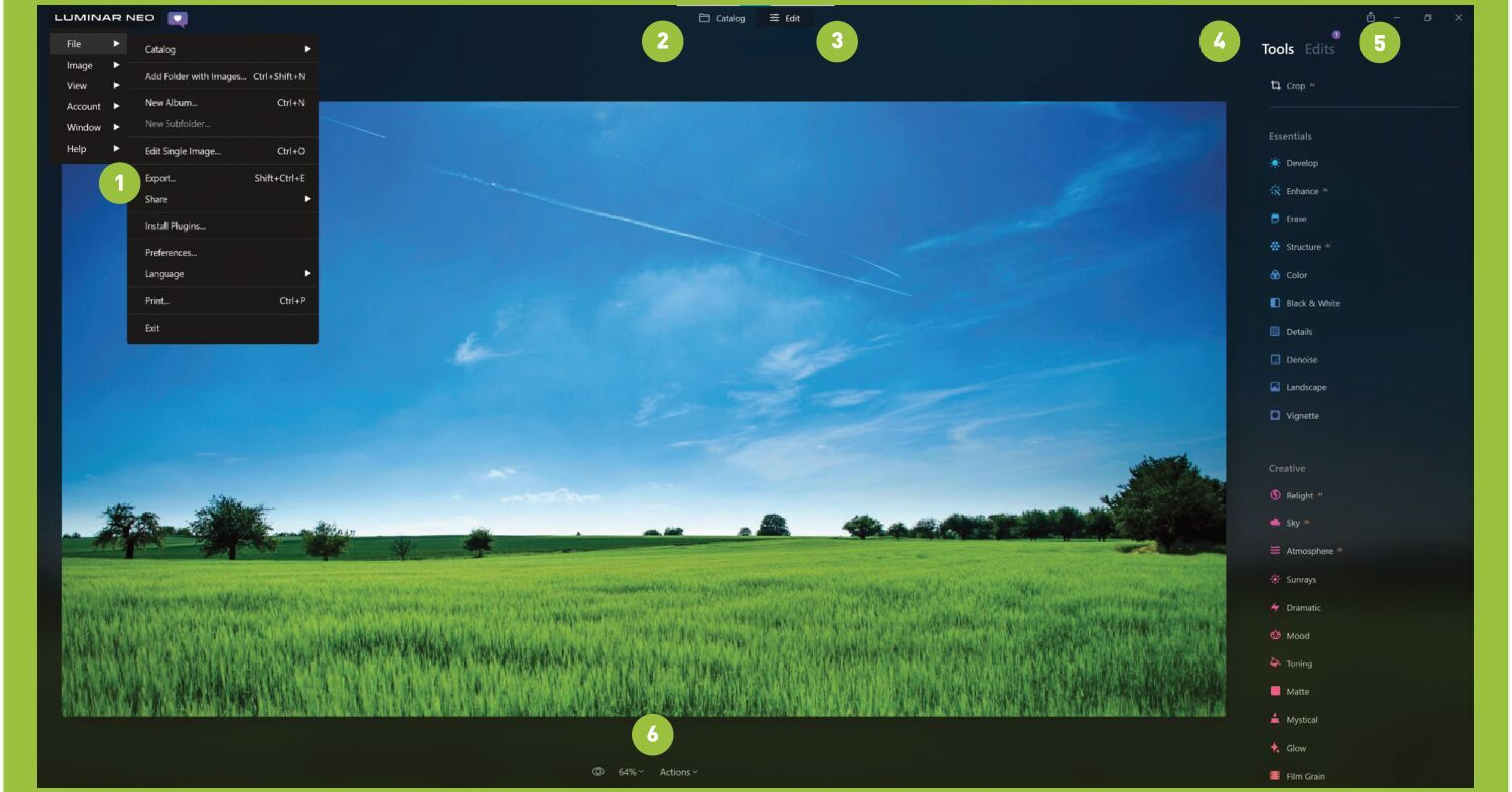
3 SKIES

Look at this incredible sunset [**Image C**]. It's totally fake. The original (see boxout) was a rather lovely blue sky from near the middle of the day, with little in the way of shadows and a few clouds and airplane contrails. Using Luminar Neo's Sky AI—found just below Relight AI in the Creative section—we can replace the whole sky, then relight the rest of the image to match. There are a large number of skies built into the application, from sunny days to sunsets and nightscapes. You can choose to add your own or you can follow the 'Get More Skies' link to the Skylum marketplace, where you'll find packs



© LUMINAR-NEO

THE LUMINAR NEO INTERFACE GUIDE


LUMINAR NEO
File
Image
View
Account
Window
Help
Catalog
Add Folder with Images... Ctrl+Shift+N
New Album... Ctrl+N
New Subfolder...
Edit Single Image... Ctrl+O
Export... Shift+Ctrl+E
Share
Install Plugins...
Preferences...
Language
Print... Ctrl+P
Exit
Catalog
Edit
Tools
Edits
Crop
Essentials
Develop
Enhance
Erase
Structure
Color
Black & White
Details
Denoise
Landscape
Vignette
Creative
Relight
Sky
Atmosphere
Sunrays
Dramatic
Mood
Toning
Matte
Mystical
Glow
Film Grain
64%
Actions
1
2
3
4
5
6

1 MENUS
Here's the dropdown menu that replaces the usual menus at the top of the interface.

2 CATALOG
Click here to find all the folders and individual images you've added to Luminar, ready to edit

3 EDIT
The editing interface is where you will spend most of your time.

4 TOOLS
A list of tools. Click on each to expand the sliders and add the effect to your image. Advanced options can be uncovered too.

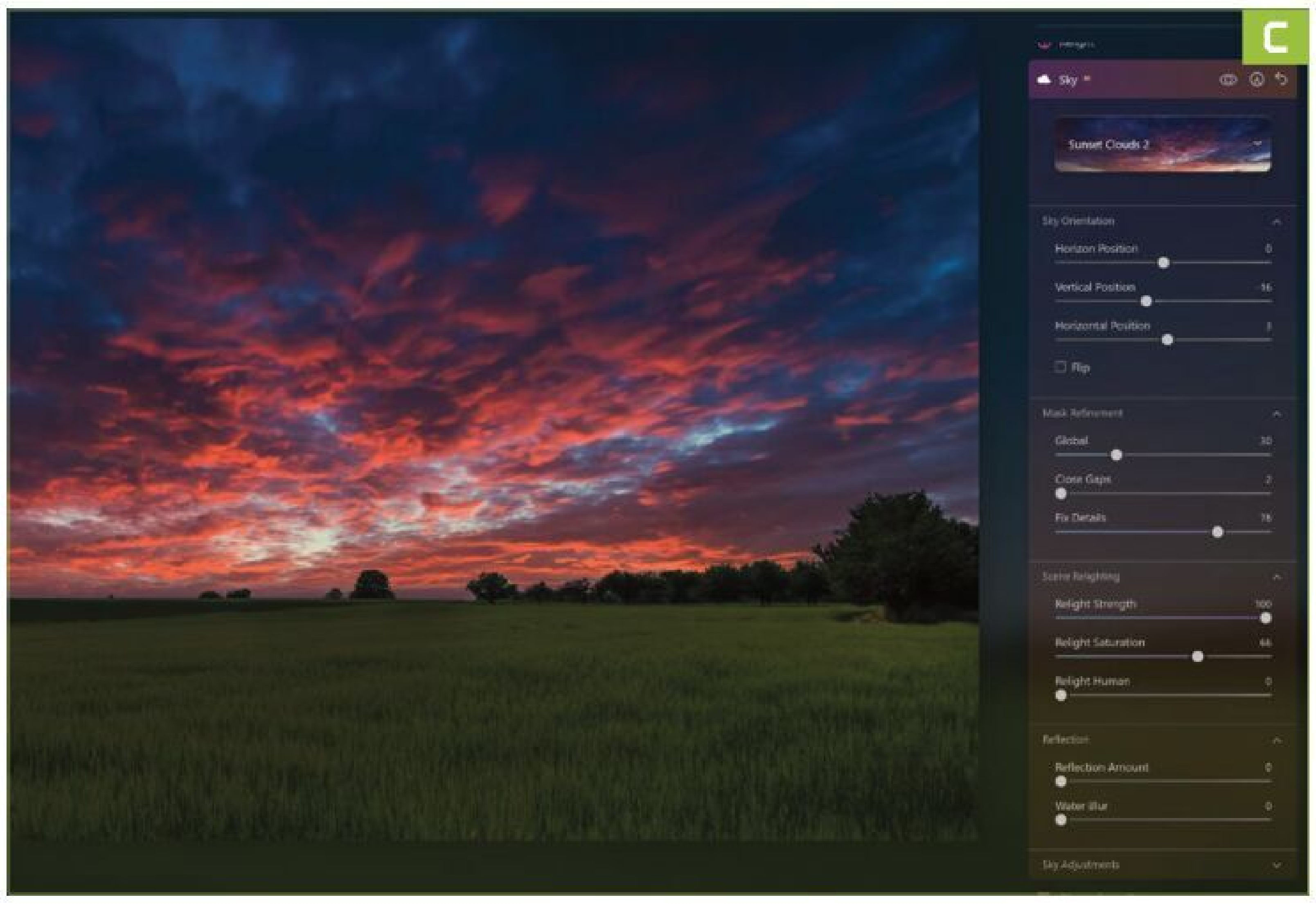
5 EDITS
A list of edits you've applied to the image. You can go back and further alter them, or remove them altogether.

6 ZOOM AND UNDO
No Ctrl+Z here, so use the Eye to view the image, the zoom menu to change magnification, and Actions to undo.

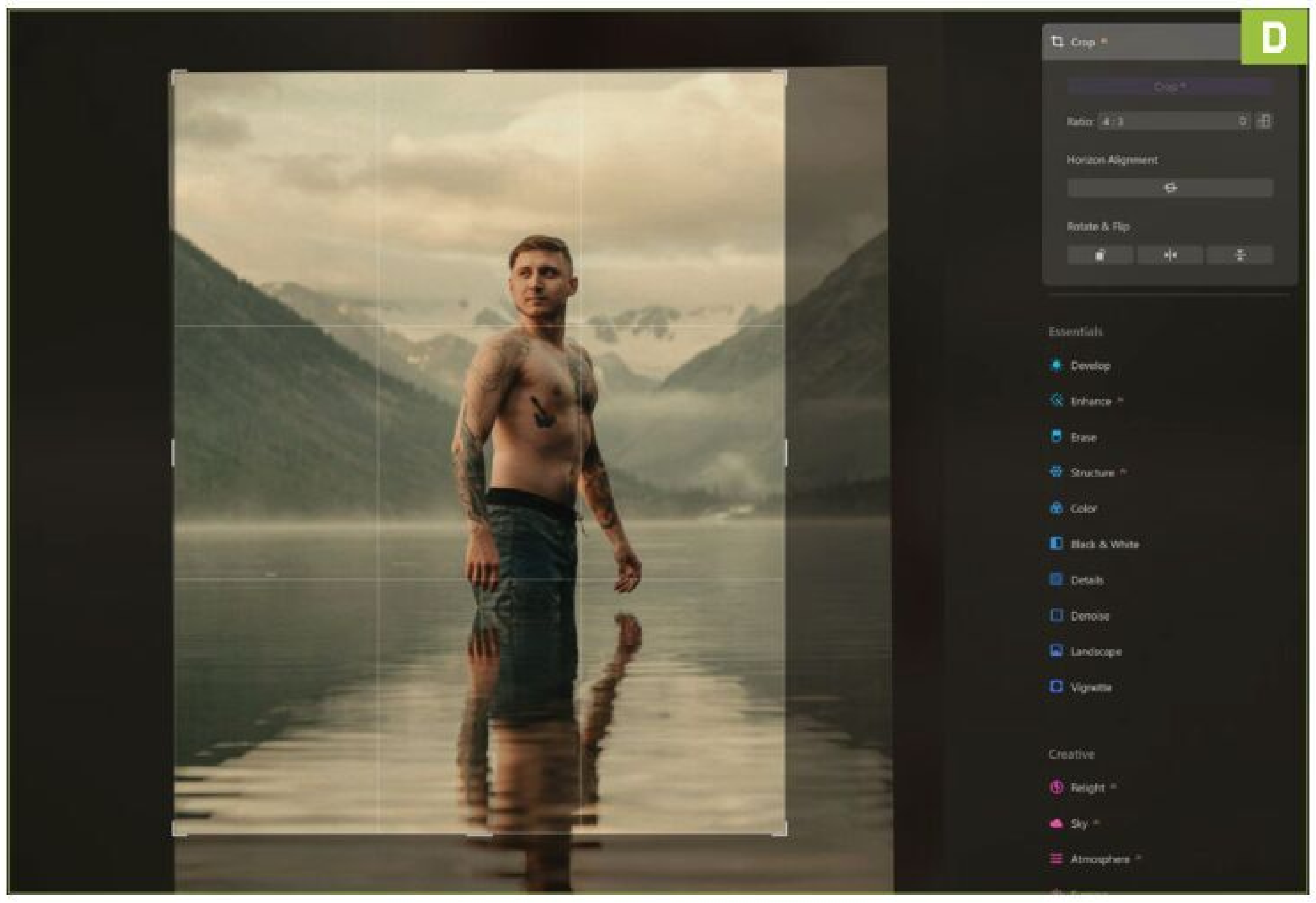
of sky photos ready for purchase and download. Some packs are free, but most cost around $40. There are clear days, night skies, northern lights, and more on offer.

›› Back to the photo editing, and once you've chosen your sky you can move it around and even flip it using the sliders in the Sky Orientation panel. Mask refinement comes next, allowing you to fine-tune the sky around trees and bits of mountain on the horizon. Then comes the good stuff—scene relighting.

›› This changes the brightness and color of the rest of the image to more closely match the sky. It's extremely clever and while it's not quite up to turning a daytime image into one that looks like it was taken at night, even if you substitute a sky with the Milky Way arching across it, the landscape takes on the hues of a sunset, or a different white balance, informed by the sky replacement. You can change its strength and saturation.


C
Sky
Sunset Clouds 2
Sky Orientation
Mask Refinement
Scene Relighting
Reflection
Sky Adjustments

Horizon Position 0
Vertical Position -16
Horizontal Position 3
☐ Flip
Global 30
Close Gaps 2
Fix Details 78
Relight Strength 100
Relight Saturation 66
Relight Human 0
Reflection Amount 0
Water Blur 0


D
Crop
Horizon Alignment
Rotate & Flip
Essentials
Develop
Enhance
Erase
Structure
Color
Black & White
Details
Denoise
Landscape
Vignette
Creative
Relight
Sky
Atmosphere

Ratio: 4:3

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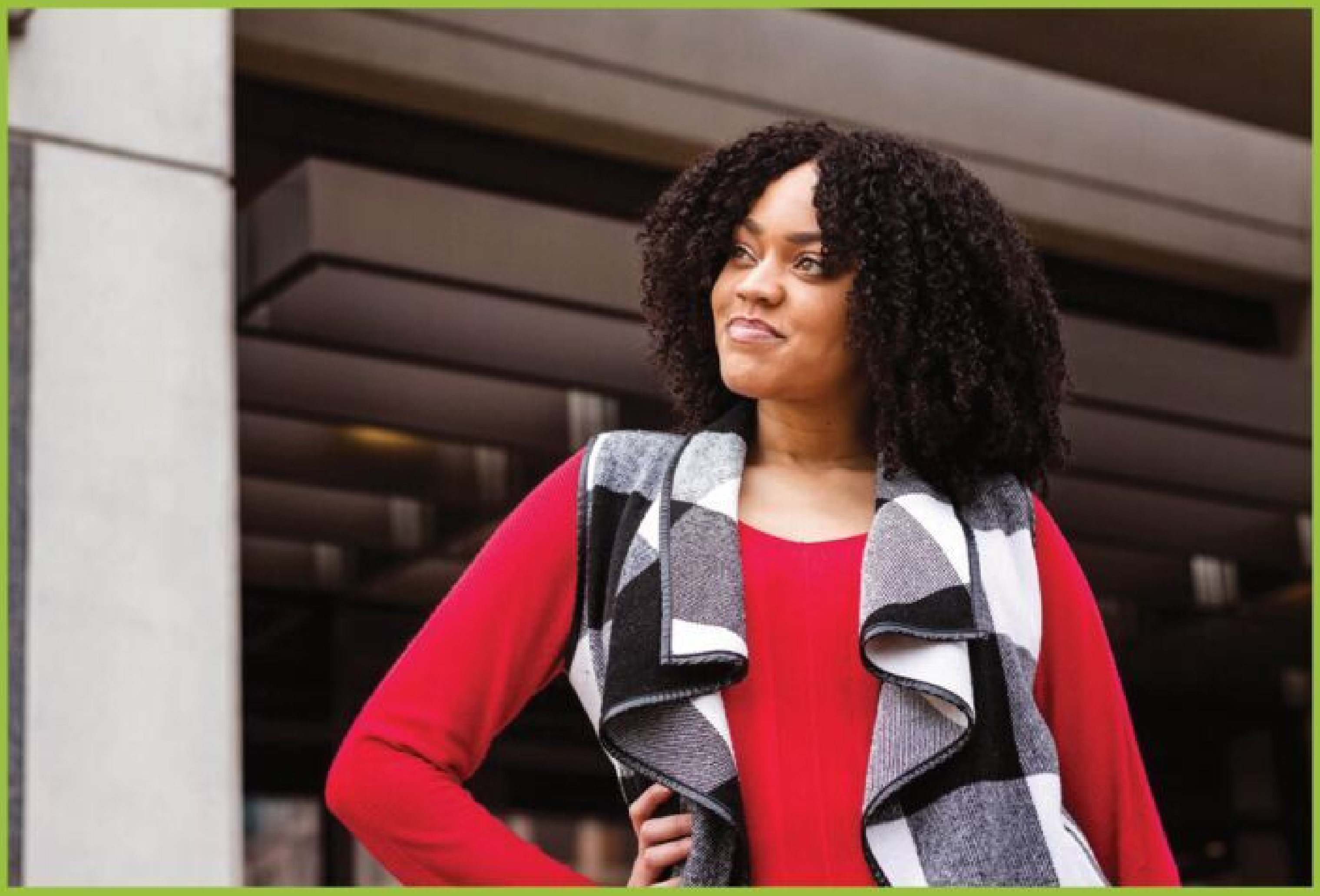
VIEWS TO A THRILL



This version of Luminar seems to have removed the useful 'before and after' view that allowed you to split an image with a movable boundary. Not only was it perfect for seeing precisely what had changed in your image, but for journalists preparing tutorials it allowed an effect to be shown in a single screenshot. So the pictures in this boxout are the original ones we used for two of the Luminar effects on these pages, for comparison with the finished articles above. We hope the split view returns for the full retail version, as it was one of the things that set Luminar apart from its competition. However, the ability to flip back to the original image by holding down the eye icon at the bottom of the interface or on the Tools panels and use the arrow icon to undo all your work, remains.

© ÁKOS SZABÓ, CREATEHERSTOCK, DMITRIY GANIN

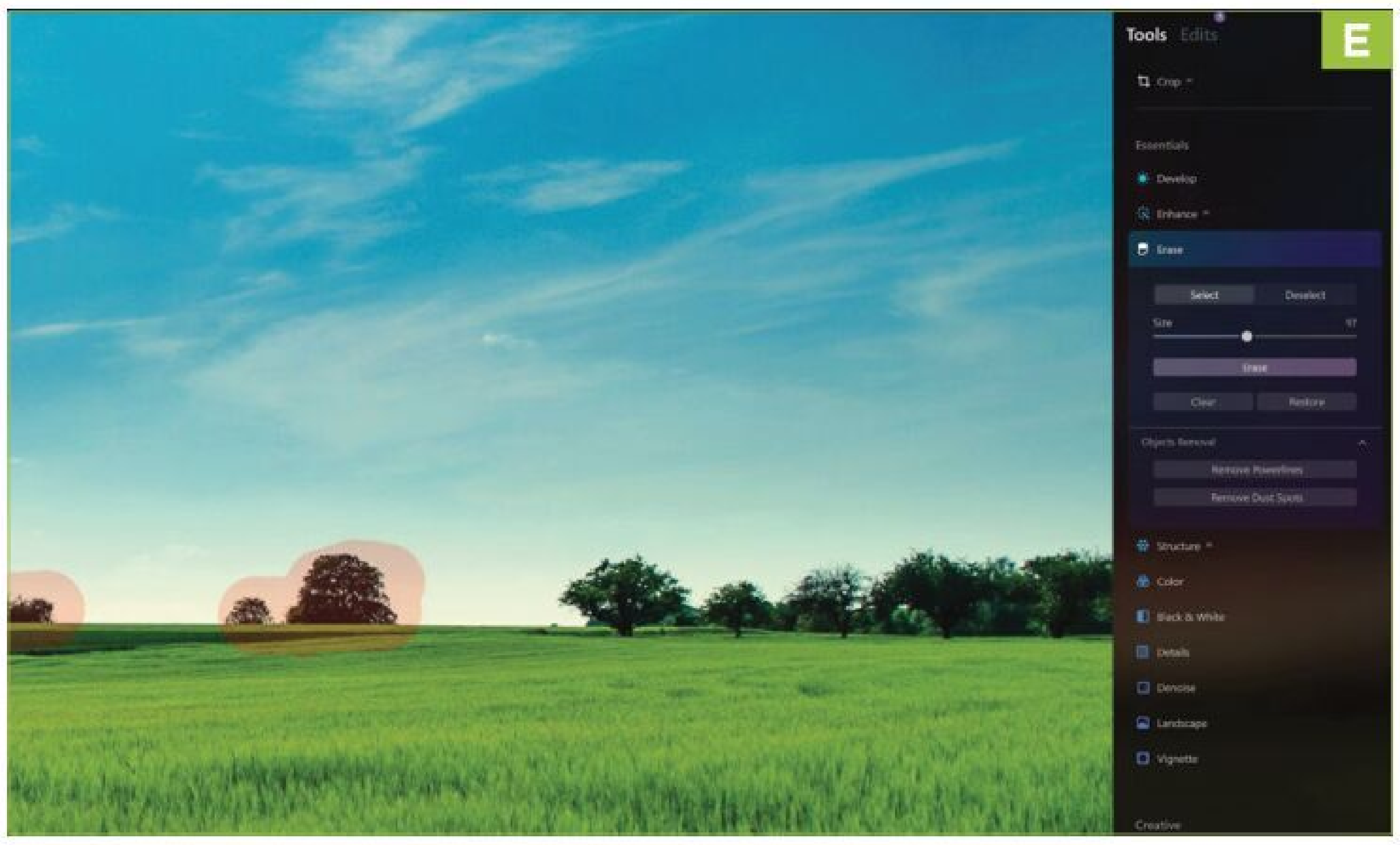
›› If there's a figure in your scene, the Relight Human slider singles it out for special treatment, changing its colors against the background so it stands out as the subject of your image. Is there water in the scene? No problem. Luminar recognizes it and reflects the new sky there, allowing you to control how much reflection there is, and how blurred it becomes.

4

ATMOSPHERE

This is a strange one, as it paints your image with a background fog. The fog goes behind any strong subjects, such as people, but will paint over the top of replaced skies. You're given a few choices for your misty weather effects, including fog,

techradar.



mist, haze, and a layered fog that keeps more of the background visible. Perhaps it will be useful for capturing some cozy fall ambiance in your images, but it's also good for covering up bits that don't quite mesh together.

5 CROP

There's hardly any image that can't be improved with a judicious crop, and so Luminar has improved its cropping tool to help you out. Use the Crop AI button and not only will it suggest a crop, but it will also rotate the image slightly to straighten a wonky horizon and crop into all kinds of aspect ratios [**Image D**], including those for Facebook cover photos and wall posts. There are Instagram-friendly squares too, or you can input your own values. From here you can also rotate and flip your image.

6 ERASE

The Erase tool, which functions in a similar way to Photoshop's content-aware fill or healing brush, has been upgraded to automatically remove dust spots on an image that are caused by dirt on a camera's sensor. It can also target any power lines in your shots, or you can paint over any object and have it filled in. We found it was particularly good at removing trees from the skyline of the landscape shot [**Image E**] but less useful in the contrails in the sky, where it left a smeary line. ⏻

© LUMINAR-NEO

FILE HANDLING

There's no such thing as File → Open in Luminar, so to get your images into the app, it's easiest to add a folder like Pictures, into which you export images straight from your camera or from a raw processor, such as Lightroom. There is also an Edit Single Image option for a file somewhere else on your storage. Click the Luminar Neo logo in the top left and you'll find the familiar menus. From there, Choose File, and you'll be able to add a folder or file to the app.

Luminar has always stood apart from other image editing apps, preferring to spread its icons across its interface and refusing to pop up a tooltip when you hover your mouse pointer over an unfamiliar pictogram. This is changing, however, as not only do tooltips now appear in Neo when you hover over the Zoom and Restore to original buttons but most of the icons that once peppered the interface have been swept away. This is a pre-release version of the software, however, so they could return.

Luminar is a non-destructive editor (meaning you can make changes without overwriting the original image), so you must export a new version of your edited image rather than saving it. This is found in the File menu, where you can also access the new Luminar Share functionality, which syncs your images to a smartphone app.

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BUILD IT

GUY COCKER, EDITOR-IN-CHIEF

Frankenbuild! Turn Old Into New

It's alive! Raiding the Maximum PC stock room

LENGTH OF TIME: **2-3 HOURS** | LEVEL OF DIFFICULTY: **MEDIUM**

THE CONCEPT

AFTER A SUCCESSFUL first month at the helm of *Maximum PC*, I was alerted to the 'situation' in our stock room, where graphics cards, RAM, and keyboards (so many keyboards!) were pouring out of the door. As I got to cataloging everything and trying to match motherboards with their boxes, the idea struck me—why not try to turn some of these unused and unloved parts into my first build?

The result is this marvelous Frankenstein of a computer, a triumph for gaming and productivity built from parts otherwise going to waste. That meant that the difficulty and length of the build went up slightly, as we had to search high and low for the right cables, while some parts were too big for the case and other parts didn't work at all. There's also more RGB than we'd expect to find in the average attic, but the challenge was to use what was to hand, and we had an abundance of lighting.

This wasn't an exercise in showing off how much cool stuff we get to play with on *Maximum PC* (although that certainly is fun), but rather a chance to make something functional out of dormant old parts. You too might have components lying around that you could repurpose, either for free or with a little outlay on missing items. In just a couple of hours, you could make a media center PC for the living room, a gaming PC for a friend or relative, or an office computer to donate to a local charity. We'd love to hear your stories on repurposed gear, so if you've built something similar, let us know and we'll feature the best in an upcoming issue.

But without further ado, let's get on to how we put together our rather attractive Frankenstein PC, and how I tackled my first build for *Maximum PC*.

THE INGREDIENTS

SOME OF THE BIGGEST items in our stock cupboard were cases, so I had a few options. My first choice was the gorgeous NZXT H1, an Xbox Series X-style case we featured on our September 2020 cover. However, as a Mini-ITX case, it would limit my choice of motherboard, cooler, and maybe even graphics card. Ultimately, I settled on the Corsair 4000D Airflow, a standard size case.

The motherboard and RAM came together as an item, so had probably featured in another build from a previous issue. The Asus ROG X570 Crosshair VIII Hero Wi-Fi is a mid-range board with plenty of features, including Wi-Fi and double M2 SSD slots, while the AMD Ryzen 9 3900X is a high-end processor that comes with an air cooler, although locating the latter proved impossible.

Luckily, we had a couple of AIO cooler options for the CPU. I wanted to use the Raijintek EOS 360 RBW, but it was too large to fit in the case. So I went for a Corsair iCUE H150i ELITE CAPELLIX 360, a smaller cooler we've recommended many times before.

The graphics card was an easy choice, as there weren't many around. The Gigabyte GeForce RTX 2070 GAMING OC 8G is a few generations old, but still has plenty of grunt. The power supply caused the most grief. I chose the Seasonic PRIME SSR-600TL, but alas, it wouldn't turn on so I settled on the EVGA SuperNOVA 1200 P2, an overpowered 1200W PSU for this build, but it works.

I had loads of options for RAM but settled on 32GB of 3733MHz HyperX Fury RGB. The SSD was a Corsair Force Series 2TB M2 drive, which will be more than enough. I toyed with adding a 4TB WD Red SATA SSD or a 12TB Seagate BarraCuda 3.5-inch hard drive but couldn't find the mounting for the case. C'est la vie!

INGREDIENTS

PART		STREET PRICE
Case	Corsair 4000D Airflow	**$80**
Motherboard	Asus ROG X570 Crosshair VIII Hero Wi-Fi	**$390**
CPU	AMD Ryzen 9 3900X	**$445**
GPU	Gigabyte GeForce RTX 2070 GAMING OC 8G	**$630**
Memory	HyperX Fury RGB 32GB (2 x 16GB) 3733MHz	**$195**
PSU	EVGA SuperNOVA 1200 P2	**$220**
Primary Storage	Corsair Force Series Gen.4 PCIe MP600 2TB NVMe M.2 SSD	**$286**
CPU Cooler	Corsair iCUE H150i ELITE CAPELLIX 360	**$160**
OS	Windows 10 Home 64-bit OEM	**$32**
Total		**$2,438**

1

AWARD-WINNING BUDGET CASE

IF THIS CASE LOOKS FAMILIAR, it's because it's been our Budget Build recommendation in every issue since Holiday 2020, when we introduced it as "simple but effective". I'd add stylish and sturdy, and it even features a USB 3.1 Type C port in its I/O. Crucially, it has space for a full-size 360 AIO cooler at the front, there's plenty of room to work in, and the cable ties keep everything tidy. The retail package comes with two Corsair 120mm AirGuide fans, although in the spirit of the Frankenstein build, only one was in the case. So I took the side panels off, kept that fan as the exhaust, and left the roof of the case empty, but ready for more fans if needed.

2

AIO PROBLEMO

I HAD THE CHOICE of two AIO coolers from the cupboard, the Corsair iCUE H150i Elite Capellix 360 ($170) to match the case, or the cheaper Raijintek EOS 360 RBW AIO Water CPU Cooler ($120). Both offered RGB lighting, although the Raijintek didn't come with a lighting controller like the Corsair. We've never built with the Raijintek, so I went for that, but disaster struck—it was too tall to go into the case because the front-mounted I/O cabling blocked it. We tried the Corsair instead, which fitted perfectly. This cooler is the one we use in our high-end turbo build and is overkill for this build. For something more modest, we'd recommend the Enermax Liqmax III 240 RGB for $50 mounted to the ceiling, or even just the stock cooler included in the retail AMD Ryzen 9 3900X package.

3

LIGHT ‘EM UP

THE CORSAIR iCUE H150i Elite Capellix 360 comes with an RGB lighting and fan controller, which we installed on the reverse of the build, tucked away with the cabling. We placed it where SATA SSD drives would usually go—we had loads these drives available, but unfortunately, no mounting plates to fit any in this case. We had trouble getting the lighting controller to stay in one place, first using self-adhesive film, then opting for the more low-rent option of sticky tack. You can’t see it, so I won’t get too hung up about it. The fan controller has space for six fans, the maximum this case supports, so we could go crazy and add three more RGB fans. There was no control lead coming off the box, so we couldn’t manually control lighting, that had to be done through iCUE software in Windows once we were up and running.

4

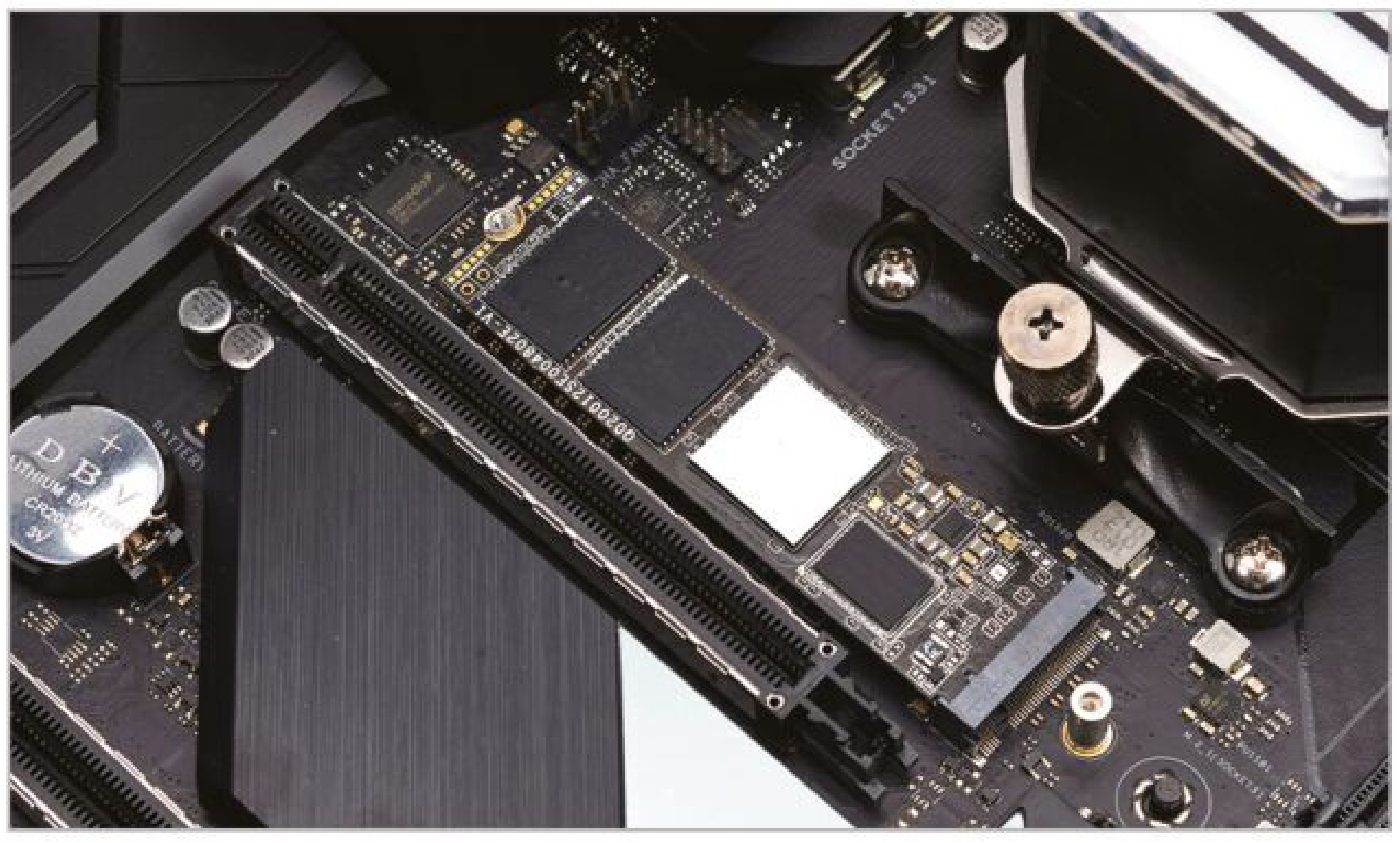
RYZEN TO THE CHALLENGE

FINDING THE MOTHERBOARD and CPU together in one piece, I could determine what the mobo was from the logo, but I had no way of knowing what the chip was as it was covered in thermal paste. There was a high chance the motherboard and CPU would be compatible (or else I’d have been worried about the mad scientist lab my colleagues were running before my arrival) but my main concern was making sure the CPU was suitable for the build. I removed the chip, applied rubbing alcohol to a cotton bud, and gave it as good a clean as I could. Upon finding out it was a Ryzen 9 3900X, I actually let out a little ‘squee’, because it’s a few years old, but still plenty powerful for a build like this. I also took this opportunity to install the mounting brackets for the cooler, as it’s less fiddly to do when the mobo is outside the case.

7

GETTING A SCREW LOOSE

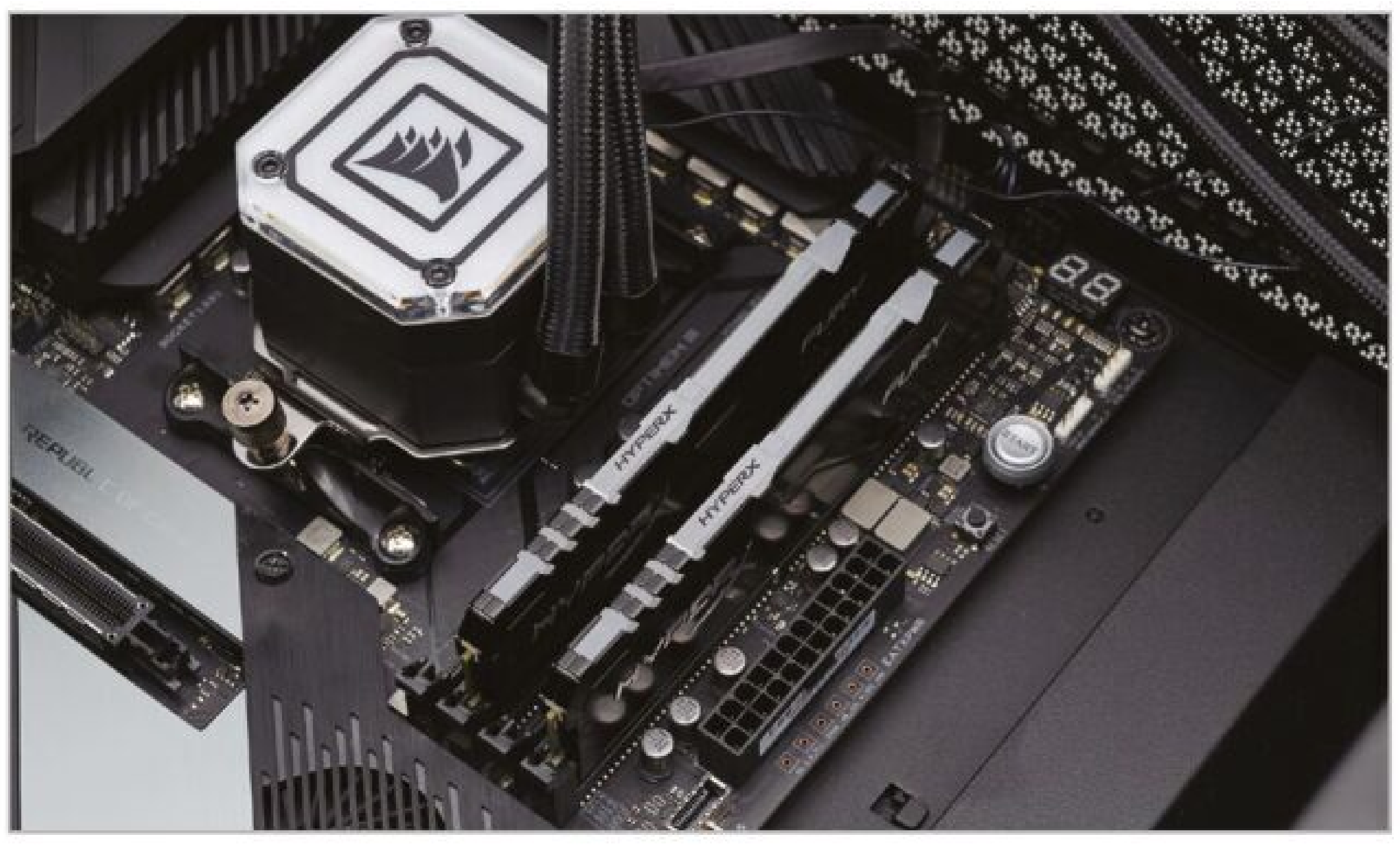
WHOEVER LAST HAD this lovely motherboard before me had screwed the M2 SSD heatsinks back on so hard that I couldn’t undo them on my first try. Thankfully, the team in the photography studio had a set of screwdrivers I could use, which is a lesson to all PC builders—always invest in good tools. With the heatsink off, I was able to install the Corsair Force Series 2TB NVMe drive I was lucky enough to find. Again, this is overkill both in terms of capacity and performance but, on a personal note, this is where I’d spend my money if I were building. I have a 2TB SSD in both my desktop and laptop systems, just because I’m incredibly indecisive when it comes to games and tend to flit between many at a time. I also do some video and audio editing, and it’s nice not to have to be constantly clearing out your document and download folders.



8

RAM RAIDING

RAM SUPPLY was an embarrassment of riches, with the option of using Crucial Ballistix Elite 16GB (2x 8GB) 3600MHz ($200), HyperX Fury RGB 32GB (2x 16GB) 3733MHz ($195), or G.Skill TridentZ 64GB (4x 16GB) 3200MHz ($320). After some input from Christian, no stranger to builds himself, I plumped for the HyperX memory at the sweet spot of 32GB. That’s more than enough for most games and applications, but not too small to throttle the memory-hungry AMD Ryzen chip. Again, there’s no reason for the RGB or faster clock speed (manufacturers clearly think we love RGB here). If you’re speccing a system out, a non-RGB 32GB 3200MHz kit from the Corsair Vengeance or Crucial Ballistix range should cost no more than $150, a 25 percent saving. When using two sticks, place them in slots two and four.



5

HOLDING OUT FOR A HERO

WITH THE CPU back in the motherboard, I screwed the main board into the Corsair case. The ASUS ROG X570 Crosshair VIII Hero Wi-Fi is a fantastically well-specced board, with Wi-Fi 6, two M2 SSD slots with big heatsinks, four PCIe slots, a USB-C port, and a 2.5G network port. There are also 11 USB-A ports, so you should never run out of places to plug in your peripherals or devices. It has everything I'd want, but if you don't need all of those fancy features, don't pay for them. I personally built an AMD Ryzen 5 3600 system at the beginning of the pandemic and used an MSI B450 TOMAHAWK MAX motherboard with it for only $150. I still have it at home and would be tempted to go for that in this build, the only downside is that it doesn't support addressable RGB, which is something of a big feature in this build.

6

ICUE'D UP THE CORSAIR

WITH THE MOTHERBOARD and the AIO cooler in the case, the next step was to connect the two together to finally start bringing this puppy to life. This was probably the fiddliest part of the build, just because I had to lie the case down on its side, apply thermal paste to the CPU, keep the Corsair cooler steady, and then screw the thing into place. It's one of those jobs that's slightly easier with an extra pair of hands, one to hold the unit steady and another to use a screwdriver to get it mounted. All things considered, it's done in a matter of minutes, and then it's a case of attaching one cable to the motherboard and another to the Corsair controller. We love the look of the Corsair cooler, which lights up beautifully when it's up and running. I fully admit it's overkill for a build like this, but forgive me for wanting to live a little!

9

OFF THE LATCH

I PROBABLY SHOULD have noticed this before now, but in the excitement of creating my first build, I'd missed the fact that the motherboard had a dodgy PCIe slot. Yes, only after getting most of the main board into place did I notice that the latch holding the card in place was missing. Annoying, but these are the sort of things that can happen when you're raiding a stock cupboard for old PC gear—they might have been to many reviewers before me. In this case, I made sure that the graphics card went into slot 1 tightly and screwed it in place. But I later decided not to risk it and opted to put the graphics card in PCIe slot 2, which in the case of this motherboard, is just as fast as slot 1. Both of the slots worked, but it's probably best to be on the safe side. We won't be running any graphics cards in SLI, so there's nothing to worry about long-term.

10

MAD WITH POWER

I FOUND THREE power supplies for this build. The Cooler Master RS650, a 650W power supply that isn't sold anymore, a SeaSonic Prime SSR-600TL 600W fanless model costing $300, or an EVGA Supernova 1200W P2 which retails for $220. I started with the CoolerMaster model to keep things simple, but when I tried to wire in the graphics card power, the cables wouldn't fit. I then chose the SeaSonic Prime silent model, my first experience with a fanless PSU, but it wouldn't power on. So after all that, it had to be the EVGA! If you're speccing an equivalent build, you can save a lot of money here. The Cooler Master MWE 650 W 80+ Gold features a similar modular design and retails for $100. If you don't care about keeping things neat and tidy, the Cooler Master MasterWatt 650W 80+ Bronze semi-modular model is a steal at just $60.

11

THE BRAIDED BUNCH

WITH THE POWER cables attached to the working PSU, I need to get the cables to the various components. There aren't many things that need connecting—no SATA drives in this build, so it's just the motherboard, graphics card, and SATA devices—in this case, the Corsair fan/RGB controller. I found these attractive red and black braided cables in the stock cupboard—they aren't necessary, but because this case has a glass side panel, it's nice to make everything look neat and tidy—apart from a small amount of thermal paste which I scrubbed off. Going round the back of the machine, Corsair has some excellent cable tidy straps, which do a great job of keeping everything out of the way. Hopefully, we won't be coming back here that often, but it'll be easy to diagnose any faults if we do.

12

COMPLETING THE BUILD

I TURNED THE COMPUTER ON, looked at the readout on the motherboard, screwed the power supply into place, then put the two side panels on. I didn't have enough screws to properly secure the power supply but the case's thumbscrews make rebuilding the machine a doddle. I attached a keyboard, mouse, and monitor but, sadly, the machine wouldn't boot up. The readout indicated it could be a memory problem, perhaps different RAM was used before and custom settings implemented in the BIOS. Either way, a BIOS reset seemed to do the trick. After that, I rebooted and went back into the BIOS to engage the RAM's XMP settings, so I could get the most out of those fast clock speeds. Then it was a case of installing Windows and the games and software for benchmarking.

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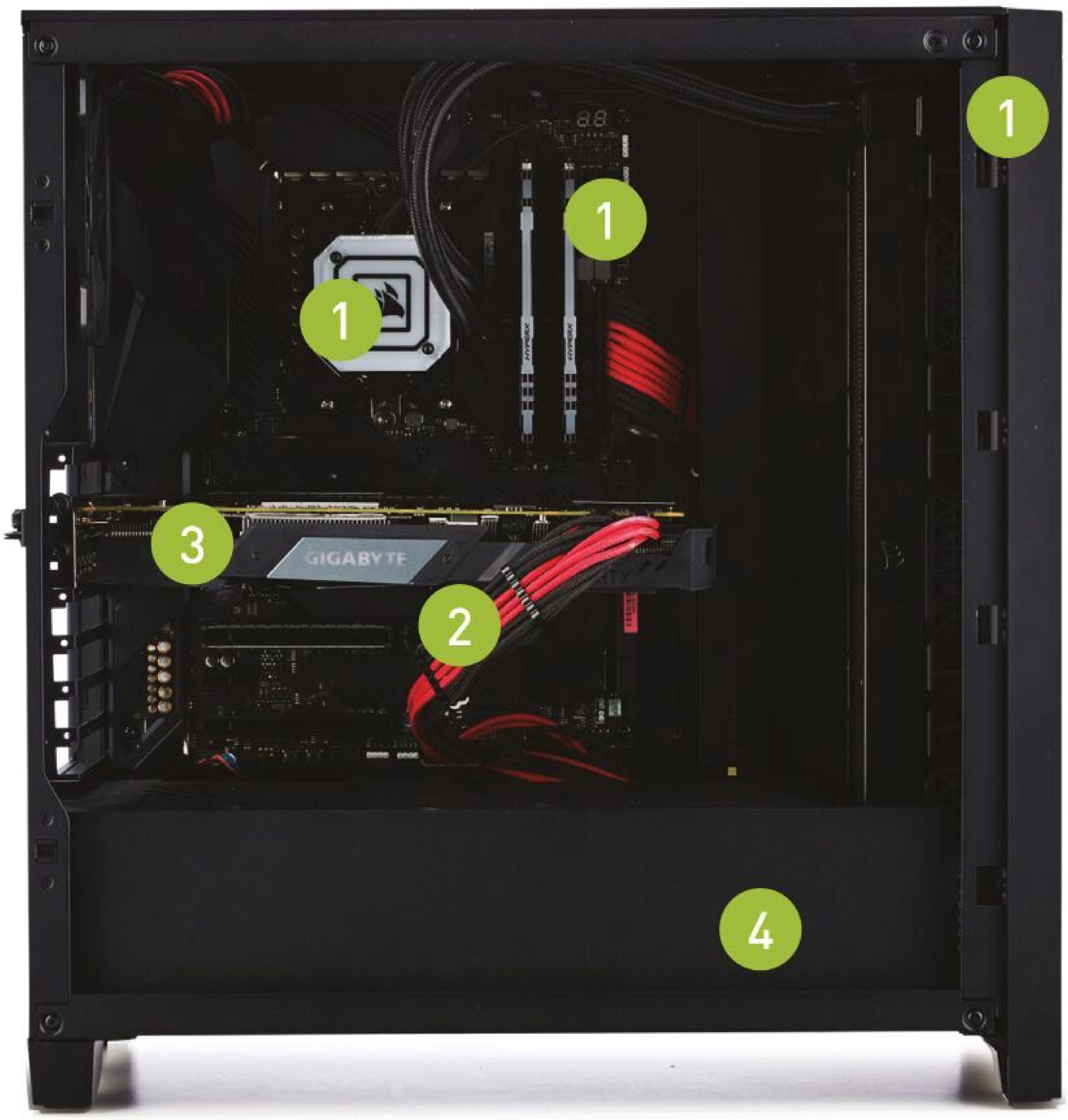
forums.pcgamer.com

PC GAMER



1 **The RGB lighting on the CPU cooler, RAM, and front case fans is definite overkill but we had to work with what we could find.**

2 **The premium black and red braided cables were a useful find for this build and they kept everything nice and tidy.**

3 **The Gigabyte RTX 2070 card looked slightly lop-sided in PCIe slot 1, which is just the nature of incorporating used parts.**

4 **The Corsair case is compact but also stylish and functional, with plenty of room to work inside. That also means it has excellent airflow.**

THE CONCLUSION

ALL IN ALL, this was a fun, if somewhat challenging build. Building from spare parts is a trial and error process that's a world away from the relative ease of using retail components. When building my own PCs, I tend to agonize over each individual part of my build for weeks, put together my parts list on PC Part Picker [https://pcpartpicker.com] to make sure they are all compatible, and then have all of the boxes in one place so that accessories and manuals are immediately to hand. With a Frankenstein build, it's much more of a case of trial and error—just make do with what you have, plug it all together as best you can, and hope for the best!

That said, this is certainly a machine that I would give to someone who wanted to game at 1080p or probably more likely use myself as a gaming PC in my living room. I've really gotten into couch PC gaming over the last couple of years, and this machine loaded with games and running in Steam Big Picture mode would be an absolute dream. Sadly, it won't run games in 4K, but it'd be perfect for multiplayer games and VR titles—a Beat Saber party using this PC would go down a storm, for example.

In terms of learnings from the build, I would have really liked to have added more hard drives, because there were so many spare SATA SSDs and 3.5-inch hard drives in storage that I could use. I imagine that's the case for many readers too—if you're going to have any spare components in a drawer somewhere, I suspect it's hard drives.

I could have added a second M2 drive onto the motherboard in this build, but I'd have needed to order new mounting brackets for the case in order to fit any SATA drives. With another SSD or 3.5-inch drive, I could have stored more games, used the computer as a server, or put on a load of media on it if I was repurposing it as a media center PC.

I also need to be totally honest with myself about one aspect of the build, and that's the fact that few people are going to have a graphics card lying around like we did. Given their coveted nature and astronomical value over the last couple of years, you'd either have sold it or, you know, used it yourself.

That said, the RTX 2000-series still shouldn't be overlooked in 2022. Sure, the RTX 3050 (read our review on page 74) is cheaper at retail if you can find it, but it's not up to the performance of the RTX 2070, which is still more than capable of 1080p gaming at high settings (see benchmarks). It's also a good candidate as a second machine for Twitch streamers, as it boasts H.265 hardware encoding.

This is the first PC I've built in a year, and while there were some frustrating moments, it was a reminder of just how fun these builds (and my job!) can be. I'll see you soon for the next one!

BENCHMARKS COMPARISON

	ZERO-POINT	
3DMark: Fire Strike (Index)	19,267	21,145 (10%)
CineBench R15 Multi-Thread (Index)	2,034	3,014 (48%)
CrystalDisk Q32T1 Sequential Read (MB/s)	3,103	4,931 (59%)
CrystalDisk Q32T1 Sequential Write (MB/s)	1,053	4,210 (300%)
Total War: Warhammer II (fps)	77	98.4 (28%)
Rise of the Tomb Raider (fps)	122	118.9 (-3%)
Tom Clancy's Ghost Recon: Wildlands (fps)	68	67 (-2%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an Intel Core i9-9900K, 16GB Corsair Dominator Platinum RGB DDR4-3600, an Nvidia GeForce GTX 1080 FE, and a 240GB Corsair Force MP510 SSD. All game tests are performed at 1080p at the highest graphical profile.

LAB NOTES

GUY COCKER, EDITOR-IN-CHIEF

Gaming laptops DON'T suck

A riposte to Jeremy Laird's recent column

LET ME JUST SAY this from the outset: Jeremy Laird is a fantastic editor who did a phenomenal job managing this esteemed publication before my arrival. But, having read his column "Gaming Laptops Suck" in the February edition, I felt I had to stick up for these little portable powerhouses.

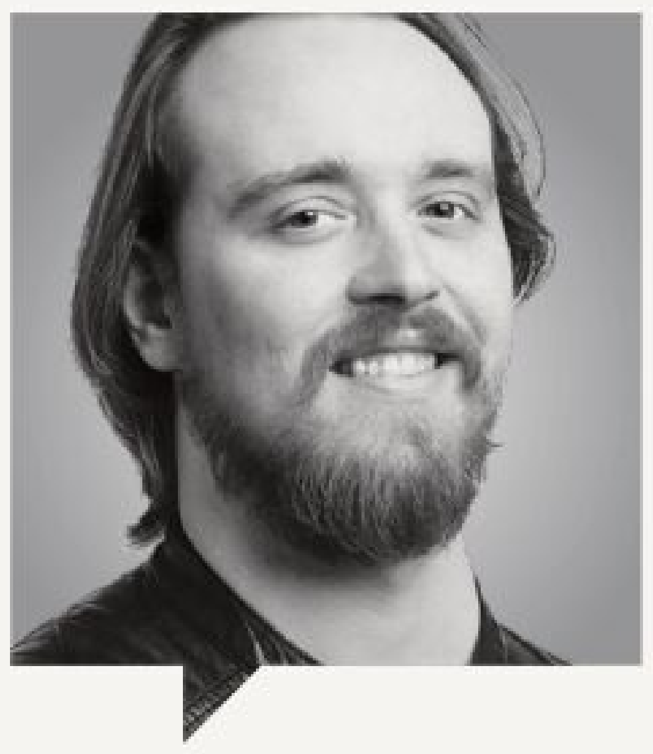
You see, gaming laptops are what got me through the pandemic. Sure, I've enjoyed gaming desktops and their ridiculous power for years, but during lockdowns, I didn't want to game in my home office, as it's where I'd been cooped up all day. So I decided to invest in a gaming laptop so I could work from the living room, the kitchen and (hopefully, my new boss isn't reading this) sometimes even my bed.

This newfound freedom meant I could rekindle my love of gaming again. Nothing on TV to watch? Not a problem, I'd play something on my HP Omen 15. Ten minutes free before dinner? Time for a game of *Gears Tactics*! Partner reading in bed? No problem—head to Scotland for a quick cruise around Edinburgh in *Forza Horizon 4*.

Jeremy's point about gaming laptops was fair—they do lack the power of desktops, they are harder to upgrade so have a shorter shelf life, and because they're being banged about on the road, they often suffer from component failure. But I will say this: my new gaming laptop, the Lenovo Legion 5 Pro, has single-handedly killed any lingering interest I had in games consoles. At home, I plug it into my 65-inch LG OLED for some gorgeous G-SYNC gaming, and now I'm back on the road again, it's like having an Xbox Series X in every hotel room I go. My desktop-bound 3090 may be gathering dust, but the laptop-based 3070 gets used nearly every night.

The Lenovo Legion 5 Pro laptop is a console-killer.

So I hope Jeremy takes this rebuttal in the spirit it's intended—an alternative view on how gaming laptops definitely have their place. Thankfully, he is completely right in his conclusion to his Mac vs. PC feature—you'll hear no argument from me there! Check it out on page 48.



CHRISTIAN GUYTON

Staff Writer

If you're one of our many eagle-eyed readers, you may have noticed one section of the magazine is absent this issue. The hardware teardown, produced in conjunction with our friends at iFixit, isn't featured. Don't worry, it'll be back shortly with a fantastic repair guide to a particularly hot new product, but we decided to take a break this issue in order to feature a Centerfold on page 46 of a product we couldn't resist.

On a personal level, editing the teardowns has always been one of my favorite assignments. It's fascinating to see what makes the tech we take for granted tick and to understand exactly how the most intricate pieces of hardware fit together. iFixit's website is well worth a look for its non-teardown-related articles; in fact, their handy repair guides gave me the confidence to attempt to repair my partner's Google Pixel, which recently suffered a broken screen. As terrifying as it was to pry away the broken glass with tiny plastic tools I'd bought on eBay, it came with a certain sense of pride and was certainly preferable to having it fixed by my local repair cowboys.

We've had lots of reader feedback on what you'd like to see more of in *Maximum PC* (see Comments on page 94). I'd love to revive the Head To Heads or be even more ambitious and create something new. If you have any thoughts, let us know!

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Editor's Pick:
McLaren, Dell and eSports in education

Could gaming help with essential life skills?

SO HOW'S THIS for an offer? As part of Intel and Dell's drive to get young people into eSports, I was recently invited to the McLaren Center in the UK. As a tech geek, this was exciting enough but, as a petrolhead, it was an opportunity I couldn't refuse. McLaren is one of the leading names in the motor racing world, so I was excited to check out its headquarters. I'm happy to report that it didn't disappoint. Arriving there was like landing in Tony Stark's workshop from *Iron Man*.

The day started with a look at McLaren's racing heritage, from the early days of Bruce McLaren up to the present Formula 1 team. Seeing the cars driven by the likes of Ayrton Senna and Lewis Hamilton close up was special and a real insight into the design work that goes into these incredible feats of engineering. But then we were whisked away to talk about the real highlight of the day, eSports in education.

Research by Dell Technologies and Intel has shown that the huge interest in eSports is making its way into mainstream education. For years, there's been a negative stereotype when it comes to gaming and education. Parents often assume that gaming will get in the way of their child's learning, rather than help them develop key life skills. So when the idea of bringing eSports into education first arose a few years ago, many parents assumed that this meant their kids would be playing games at school. However, eSports is experiencing phenomenal growth and, according to the Entertainment Software Association (organizers of the E3 show), the games industry was larger than movies and music combined in 2021.

The popularity of eSports could see it play a role in education.

© DELL INC, THQ NORDIC

With the potential for team-building and problem-solving being taught through eSports, more parents are now on board. Many children will already appreciate the benefits of gaming on their development, even if they are having too much fun to appreciate the cognitive benefits. Dell explained that the enjoyment of games has an enormous impact on learning—educationally, eSports are similar to regular sports, with the benefit of being more accessible. With companies such as Dell and McLaren backing this move and opening it up as a topic for discussion, it should help educate parents and lead to eSports being used in classrooms in future.

To demonstrate the point, the day ended with us trying out an F1 racing simulator room powered by Dell's Alienware gear, where we met members of the McLaren Shadow Project racing team. If only school had been like this when I was there, I'd have paid more attention in class! **–SL**

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EVGA GeForce RTX 3050

RTX goes mainstream, sort of

COMPARED TO the relative travesty of the RX 6500 XT launch (see review on page 80), the RTX 3050 feels like another great option from Team Green. Nvidia's RTX cards previously bottomed out at $300 with the later RTX 2060 models and the minimum price for the entry-level 3000-series has now dropped to just $250—in theory. The problem is that the base MSRP only applies to GPUs using Nvidia's reference clocks. If a graphics card manufacturer provides even a tiny one or two percent factory overclock, MSRPs skyrocket to $330 or more—and even then, most RTX 3050 cards are selling for more than their MSRPs.

It's the same problem with virtually every other graphics card during the last 18 months, and while we can hope the situation will improve, that could take another year or more. At least with the RTX 3050, most cryptocurrency miners should give it a pass. With the latest drivers and LHR locks in place, the card managed just 14 MH/s in Ethereum, half of the expected rate as the LHR limiter was currently fully functional. At that rate, it would earn less than $0.50 per day and would take 500 days to break even.

But it's not just miners buying graphics cards and, unfortunately, supply of the RTX 3050 has once again been completely insufficient to satisfy demand. That's despite the fact the overall performance ended up coming in behind the previous generation RTX 2060 and definitely behind the newer RTX 3060 as well as AMD's RX 6600—you can see the RX 6600 numbers in the 6500 XT review's table.

CHIP CHOPPED

At least Nvidia didn't completely castrate its latest GPU, though it's interesting to note that it is using a partially disabled GA106 instead of the GA107 chip used in the mobile RTX 3050 and RTX 3050 Ti. Nvidia apparently wanted the full x16 interface that the GA106 provides, so GA107 remains a mobile-only solution for the time being. Like all other Ampere GPUs, the RTX 3050 also has full AV1, AVC, and HEVC codec support for streamers.

One aspect of Nvidia's RTX brand that can't be understated is the importance of DLSS. Sure, there are alternative upscaling algorithms, but it looks better and is supported in far more games than FSR right now. For example, it's used in six of the ten games in our test suite—even in the highest quality mode, it still boosts performance by 20 percent on average, while the balanced mode provides even larger gains. Streamers will likely also appreciate Nvidia Broadcast, which also requires the RTX tensor cores and provides some AI-enhanced filters and noise removal.

The only real problems with the RTX 3050 are retail availability and actual street prices. Considering performance ends up trailing the RTX 2060 and RX 6600, those cards should provide a hard cap on the prices people will be willing to pay for an RTX 3050. The average price for a 2060 on eBay sits at nearly $500 and the same goes for the RX 6600. The RTX 3050, meanwhile, goes for closer to $450. Things may improve in the coming months but the next step up, the Nvidia RTX 3060, still sells for $675—the price we'd be paying for factory overclocked RTX 3070 Ti cards if things were normal.

In the meantime, we can look forward to the RTX 40-series and AMD's RDNA 3 cards, and before those arrive, we should finally get to see what Intel can bring to the table with its Arc graphics cards. Performance from the 3050 is low enough that Intel ought to be able to surpass it, but we still don't know what Intel will charge for its GPUs. As a newcomer to the discrete graphics card market, Intel will likely have to deliver better performance at a lower price to compete. We should find out in the next month or two where Intel's Arc will land. **–JARRED WALTON**

BENCHMARKS

	RTX 3050	RTX 2060	RTX 3060
10 Game Average (fps)	80 / 48	87 / 52	**107 / 66**
Borderlands 3 (fps)	113 / 54	121 / 59	**154 / 73**
Control (DXR)	52 / 33	57 / 36	**75 / 46**
Cyberpunk 2077 (DXR)	27 / 21	27 / 20	**38 / 30**
Far Cry 6 (fps)	98 / 74	111 / 83	**130 / 97**
Flight Simulator (fps)	75 / 47	87 / 54	**105 / 66**
Forza Horizon 5 (fps)	95 / 55	104 / 49	**122 / 72**
Horizon Zero Dawn (fps)	103 / 72	110 / 79	**143 / 100**
Minecraft (DXR)	36 / 31	40 / 35	**50 / 44**
Red Dead Redemption 2 (fps)	103 / 50	111 / 57	**136 / 69**
Watch Dogs Legion (fps)	94 / 47	103 / 46	**119 / 64**

Best scores are in bold. All testing conducted with a Core i9-12900K, MSI Pro Z690-A WiFi DDR4, 2x16GB DDR4-3600 CL16, 2TB Crucial P5 Plus M.2 SSD, Cooler Master MWE 1250 Gold V2. Scores are average framerates at 1920x1080 medium / 1920x1080 ultra, with ray tracing enabled in Control, Cyberpunk, and Minecraft.

VERDICT
7

EVGA GeForce RTX 3050

+ LEAN 8GB VRAM; DLSS; Good 1080p performance.

− SKINNY Slower than the 2060; overpriced custom models.

$250, http://www.evga.com/

SPECIFICATIONS

Architecture	GA106
Lithography	Samsung 8N
Boost Clock	1,777 MHz
GPU Cores	2,560
Memory	8GB GDDR6
TFLOPS FP32	9.1
Bandwidth	224GBps
TDP	130W
Connectors	1x HDMI 2.1, 3x DisplayPort 1.4

EVGA
GEFORCE RTX

EVGA's RTX 3050 XC Black delivers all you need but nothing extra, with a suggested retail price of just $250.

CORSAIR
ONE

The One's design hasn't needed updating in the past four years.

Corsair One i300

Updated for 2022 and still incredible

LET'S NOT MINCE words here: the Corsair One series is absolutely amazing and has been since its debut way back in the heady days of 2018. Is it still the best compact gaming PC we've seen? It sure is! Does it still pack the latest high-end components? It sure does! Is the price point still high enough to make your bank account start crying? You bet!

Yes, the Corsair One i300 is here, a hardware refresh for our favorite tiny powerhouse that comes with an eye-watering price tag of a shade under $5,000. This model has the latest Core i9-12900K processor from Intel, a 16-core chip with a 5.2GHz overclock, as well as an Nvidia RTX 3080 Ti and a hefty 64GB of DDR5 RAM. On paper, it's an excellent selection of components, and the i300 leverages them all for top-of-the-range performance across all arenas.

In case you missed our reviews of previous iterations, the Corsair One's big selling point is simple—its unique vertical design allows it to occupy an impressively small footprint of just 7-inches by 8-inches, leaving you plenty of tabletop real estate to work with, without sacrificing performance. The One's compact nature is achieved thanks to a flexible PCIe riser for the graphics card and specially-designed AIO coolers for the CPU and GPU, connected to a single exhaust fan at the top of the column.

This clever layout is not without its drawbacks though. The Corsair One's chassis has barely changed since its introduction (barring the removal of a front-facing HDMI port in favor of USB-C) and is predominantly constructed from metal. With only one exhaust fan to handle cooling and precious little space for heat to dissipate inside the case, the i300 gets seriously hot when running under load. Performance throttling didn't seem to be an issue in our testing, though, and we have to admit that the i300 is remarkably quiet for such a powerful machine.

CASE PACKED

One issue that still remains is that the compact configuration essentially bars you from making easy piecemeal upgrades to your system, a major selling point of many pre-built gaming PCs. Where the average pre-built rig from EKWB or Cyberpower (or even Corsair itself) generally makes it easy to swap out components when you want a performance boost or a quick repair job, the One's cramped interior makes replacing any parts challenging. Swapping out the memory or SSD is doable but tricky enough; trying to replace the GPU is a serious undertaking.

Unsurprisingly, the i300 dominates in gaming performance at 4K thanks to its powerful RTX 3080 Ti GPU. Even beyond our listed game benchmarks (soon to be updated, fear not!), we tested other games, such as *Red Dead Redemption 2*, *Total War: Three Kingdoms*, and the punishing RTX-enabled *Metro Exodus* benchmark. All stayed stable above 60fps, even at 4K ultra settings. Esports titles, including *Overwatch* and *Valorant*, barely tickled the 3080 Ti, with framerates well into the hundreds.

General performance elsewhere was also strong, with the i9-12900K blazing through CPU-bound tasks. The sizable 2TB SSD is stupidly fast, with read times in excess of 7GB/s ensuring that you'll never see lengthy load times in games again. There are also plenty of rear ports to supplement the somewhat minimalist front I/O. While it might be difficult to upgrade, the i300 is on the cutting edge of PC hardware, meaning it's relatively future-proof and should guarantee great performance for years to come.

While the sky-high price is going to be a dealbreaker for many potential buyers, the Corsair One i300 is undeniably an incredible choice of gaming PC for anyone with the cash to spare. While it's billed as a gaming system, the i300 has the hardware heft for all manner of workloads, which combined with its small form factor makes it the ideal home PC for creatives and number-crunchers who like to kick back and game after a hard day's work. Frankly, we wish Corsair would let us keep it. –**CHRISTIAN GUYTON**

VERDICT
9
KICK ASS!

Corsair One i300

+ VANQUISHER Top-notch performance; incredibly compact; runs quietly.

− VANQUISHED Can get hot; upgrading is difficult; wildly expensive.

$4,999, corsair.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	2,178	3877 (78%)
CrystalDisk QD32 Sequential Read (MB/s)	3,136	7061 (125%)
CrystalDisk QD32 Sequential Write (MB/s)	2,126	5145 (142%)
3DMark: Fire Strike Ultra (Index)	6,988	12356 (77%)
Total War: Warhammer II (fps)	42	99 (136%)
Tom Clancy's The Division 2 (fps)	38	122 (221%)
Metro Exodus (fps)	37	98 (165 %)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an an Intel Core i9-7900X, 32GB G.Skill RipJaws V series DDR4 @ 3,000, an MSI GeForce GTX 1080 Ti Gaming X, and a 512GB Samsung 960 Pro PCIe SSD. All tests performed at 4K at the highest graphical profile. Metro Exodus tested at 4K at High.

SPECIFICATIONS

Processor	Intel Core i9-12900K
Graphics	Nvidia GeForce RTX 3080 Ti
RAM	64GB DDR5 @ 4,400MT/s
Motherboard	Z690 Custom
Primary Storage	2TB PCIe 4.0 NwVMe M.2
Cooling Solution	Liquid cooled CPU/GPU
PSU	Corsair 750W SFX 80 PLUS Platinum
Case	Corsair One
Warranty	Two Year Limited Warranty

IN THIS TEMPLE
AS IN THE HEARTS OF THE PEOPLE
FOR WHOM HE SAVED THE UNION
THE MEMORY OF ABRAHAM LINCOLN
IS ENSHRINED FOREVER

The Chromebase AIO 22's column conceals powerful speakers.

HP Chromebase 22

Rotation before procrastination

IF YOU'VE BEEN READING this issue of *Maximum PC* front to back (like any reasonable person would), you have probably already enjoyed our Chromebook group test feature. You might have caught the reference to non-Chromebook devices that run ChromeOS; all-in-ones, compact computers, and so on. HP's Chromebase 22 is perhaps the best example of these—a capable Chrome-powered desktop, ideal for either the home or office.

In general, Chromebases tend to look much like any all-in-one Windows PC; just a bulky screen with all the hardware tucked away behind the display. With the Chromebase 22, HP is looking to shake things up a little; aesthetic design suddenly leaps to the fore, with a thinner screen that rotates 90° degrees for vertical use and the components nestled inside a fabric-wrapped central column. It's a futuristic-looking bit of hardware that immediately catches the eye, unlike most all-in-one computers.

HP is going for broad-spectrum appeal here and the Chromebase 22 mostly lives up to that dream. No, it's not going to impress any performance-focused gaming nuts but, let's face it, no device natively running ChromeOS is going to do that. Instead, we have a flexible system that makes a solid argument for replacing a PC, laptop, or tablet for either a working professional or a younger user for educational purposes. It's ready to go straight out of the box—ChromeOS only takes a few minutes to set up and HP has included a Bluetooth keyboard and mouse for instant use.

Unfortunately, while seeming generous, the keyboard and mouse are not to snuff. While the Chromebase 22 itself is a sturdy, well-designed piece of kit, both peripherals feel cheap and flimsy in comparison. The compact keyboard layout leaves some keys feeling a bit too small (especially backspace and enter) and keypresses are spongy with little travel. Batteries aren't included either, although we have to admit that, aesthetically at least, these extras match the appearance of the Chromebase itself.

The display is a more promising feature. On paper, it's a fairly standard 1080p touch panel but the maximum brightness is excellent and color density isn't too shabby either. Switching between landscape and portrait orientation is easy, requiring only the slightest amount of effort to smoothly rotate the display, which instantly re-orients whatever is on-screen. The resolution means it isn't ideal for high-end video or photo editing, but the touch capabilities make it a breeze to use in either configuration. A 5MP webcam sits atop the display, with a three-point privacy switch that can both cover the camera and switch off the integrated microphone array.

Beneath the lovely screen, the rounded base of the Chromebase 22 contains everything else. Of particular note are the stereo speakers; the Bang and Olufsen audio provides a seriously impressive punch for music and speech, by far the best speakers we've seen on either an AIO computer or a Chromebook. Physical volume controls can be found on the side of the base, but they feel a bit redundant when both the keyboard and touchscreen can be used. At the rear, there are two USB-A and two USB-C ports along with a headphone jack. It's a decent selection, but a USB port on the screen edge would have made using flash drives easier.

Although cheaper editions with Intel Pentium processors are available, our $700 review unit comes with a Core i3-10110U and 16GB of RAM, with a 256GB SSD. We might criticize that small amount of storage on a Windows system, but ChromeOS relies more heavily on cloud-based storage so it's not as big an issue.

The i3 processor is more than capable of handling web browsing and productivity applications. In Geekbench 5, we saw a single-core performance of 945 and a multi-core score of 1956, putting it above Qualcomm-powered Chromebooks but not at the front of the pack. With Intel UHD integrated graphics, don't expect to play anything more demanding than app games from the Play Store.

We'd recommend picking up a separate keyboard and mouse if you choose to buy this, but overall, it's hard not to like the HP Chromebase 22. You don't even need the extra gubbins; ChromeOS is optimized for touch controls, and we can see the Chromebase 22 looking at home in portrait mode on a kitchen island, recipes at the ready. **–CHRISTIAN GUYTON**

VERDICT

8

HP Chromebase All-In-One 22

+ BASED Impressive speakers; clean design; good webcam and mic; rotating screen is neat.

– ACIDIC Ports are only found at the rear; included keyboard and mouse are mediocre.

$700, hp.com

SPECIFICATIONS

CPU	Intel Core i3-10110U @ 2.1GHz
Graphics	Intel UHD Graphics
RAM	16GB (2x 8GB) DDR4 @ 2666MHz
Screen	21.5-inch IPS 1080p touch screen
Storage	256GB M.2 NVMe SSD
Ports	2x USB 3.2 Gen2 Type-A, 2x USB 3.2 Gen1 Type-C, 1x 3.5mm headphone jack
Connectivity	Wi-Fi 6, Bluetooth 5
PSU	90W Smart AC Power Adapter
Optical Drive	N/A

XFX Radeon RX 6500 XT

Trimming the fat, and then some

GPU RELEASES tend to follow a pattern. First, come the 'halo' cards that pull out all the stops. Then, come the slightly lower spec, but still fast high-end cards, followed by mainstream GPUs, and eventually the budget options. The RX 6500 XT aims for the latter, trimming down pretty much every conceivable spec in pursuit of a lower cost but still an acceptable design. Unfortunately, AMD has gone too far in its pursuit this time, cutting away too much of the juicy meat and leaving meager scraps behind.

In the past, budget GPUs such as AMD's Navi 14 (RX 5500 XT) and Nvidia's TU116 (GTX 1650 Super) have stopped cutting features at a 128-bit memory interface. Thanks to Infinity Cache, AMD could get away with a mere 64-bit interface, which is normally reserved for extreme budget solutions like the RX 530 and GT 1030. Unfortunately, the net result is a new budget GPU that often ends up slower than the previous generation RX 5500 XT it's supposed to replace.

It's not just the memory interface, however. AMD delivers a card with just 4GB VRAM—technically still enough for most games, but certainly not enough to handle many of the games in our new test suite at ultra-quality settings. Ironically, at the time the RX 5500 XT launched back in late 2019, AMD posted a blog titled 'Game Beyond 4GB', highlighting the benefits of having more than 4GB of memory. It did so because the competition at the time was the GTX 1650 and 1650 Super, both of which had 4GB. Now, more than two years later, it feels like AMD has gone backward, especially considering Nvidia's RTX 3050 comes with 8GB (see review on page 74).

AMD also cut support for the AV1 codec and even dropped H.264 and H.265 video encoding, which makes the card a poor choice for budget streaming. Next, AMD limits the PCIe interface to just four lanes. Given its budget nature, this card could end up in older PCs that only support PCIe 3.0, which in our testing dropped performance another 10 percent on average, and up to 25 percent in some games. Finally, the GPU only supports two video outputs—not that driving dual displays is a likely use case for this card.

The inclusion of ray tracing hardware almost feels laughable. You can see the "WNR" (would not run) scores for Control in our benchmarks. That's because the game wouldn't recognize the GPU as being ray-tracing capable, due to its lack of VRAM. That's probably for the best, as you can see in *Cyberpunk 2077* and *Minecraft* that enabling RT effects often drops framerates into the single-digits. We don't think you need a ray-tracing capable GPU, but if you have one, you're only likely to notice the visual benefits with more demanding effects, which the RX 6500 XT simply can't handle.

It's not a complete loss, however. In overall performance, the RX 6500 XT tends to trade blows with Nvidia's GTX 1650 Super. Stick to medium or high settings and you can still break 60fps. But we can say the same for the GTX 1650 Super and RX 5500 XT 4GB, and the 5500 XT 8GB was 10 percent faster than the newcomer in our 1080p medium tests.

The best thing about the RX 6500 XT is that it's unfit for cryptocurrency mining—and slow enough in games that demand isn't as high as for other recent GPUs. The official MSRP starts at $200, and while cards at retail tend to sell for more than that, you can at least find the RX 6500 XT in stock starting at $270. The GTX 1650 Super tends to cost around $300 on eBay, while the RX 5500 XT 8GB goes for $350 or more. We'd rather take a new card purchased from a reputable retailer than a used card off eBay. **–JARRED WALTON**

BENCHMARKS

	RX 6500 XT	RX 6600	RTX 3050
10 Game Average (fps)	56 / 27	**106 / 61**	80 / 48
Borderlands 3 (fps)	81 / 37	**166 / 83**	113 / 54
Control (DXR)	WNR / WNR	48 / 30	**52 / 33**
Cyberpunk 2077 (DXR)	7 / 3	22 / 17	**27 / 21**
Far Cry 6 (fps)	83 / 44	**142 / 100**	98 / 74
Flight Simulator (fps)	65 / 39	**96 / 58**	75 / 47
Forza Horizon 5 (fps)	80 / 28	**155 / 77**	95 / 55
Horizon Zero Dawn (fps)	71 / 56	**141 / 97**	103 / 72
Minecraft (DXR)	13 / 7	25 / 19	**36 / 31**
Red Dead Redemption 2 (fps)	86 / 30	**142 / 63**	103 / 50
Watch Dogs Legion (fps)	74 / 26	**120 / 64**	94 / 47

Best scores are in bold. All testing conducted with a Core i9-12900K, MSI Pro Z690-A Wi-Fi DDR4, 2x16GB DDR4-3600 CL16, 2TB Crucial P5 Plus M.2 SSD, Cooler Master MWE 1250 Gold V2. Scores are average framerates at 1920x1080 medium / 1920x1080 ultra, with ray tracing enabled in Control, Cyberpunk, and Minecraft.

VERDICT **5**

XFX Radeon RX 6500 XT

⊞ **LEAN** Theoretically affordable; decent at 1080p medium; Infinity Cache.

⊟ **SKINNY** 4GB VRAM; x4 PCIe connection; 64-bit interface.

$200, www.xfxforce.com

SPECIFICATIONS

Architecture	Navi 24
Lithography	TSMC N6
Boost Clock	2,815MHz
GPU Cores	1,024
Memory	4GB GDDR6
TFLOPS FP32	5.8
Bandwidth	144GBps
TDP	107W
Connectors	1x HDMI 2.1, 1x DisplayPort 1.4

XFX delivers a bare bones RX 6500 XT, still occupying two slots but with only one HDMI and DisplayPort output each.

Acer Aspire Vero

Mean, green, eco machine

SUSTAINABILITY is an undeniably tricky issue for the PC hardware industry. Mining the resources needed to manufacture computer components has a significant environmental impact, and those components are shipped around the globe in pollution-spewing cargo ships and heavy goods vehicles. Then there's the energy usage; powerful PCs glug down electricity and spew out heat, with crypto mining proving to be a significant contributor to global CO_2 emissions.

One eco-friendly laptop isn't going to fix everything, but that doesn't mean it can't try. Acer has pulled out all the stops to produce its first super-green computer, the Aspire Vero. Every aspect of the Vero's design has sustainability in mind—the outer casing is made of post-consumer-recycled (PCR) plastics and the keycaps are 50 percent PCR. The chassis is paint-free to reduce manufacturing pollution. Even the packaging uses recycled paper and cardboard.

Partnering up with UK-based charity Ecologi, Acer is ensuring that 100 trees are planted for every Vero sold, carbon-offsetting the production process. They're also running a program that allows you to donate your old device when you register your Vero, at which point they will clean and repair it before sending it off to tech non-profit Computers 4 Charity.

There are a few other small design choices here that are meant to reinforce the 'reduce, reuse, recycle' mantra. The R and E keys are highlighted in yellow and reversed, which feels a little like posturing, but we can let it slide thanks to the use of standardized screws for easy access to the component panel on the underside. Upgrading or repairing the Vero is easier than most laptops; no soldered memory here, so replacing the drive or RAM is a cinch.

In terms of build quality, the Aspire Vero feels solid—perhaps not the most robust laptop we've reviewed, but durable enough. The hinge is sturdy, and despite the all-plastic chassis, we'd wager that the Vero could handle a few knocks. The trackpad is large and glossy, clicking feels responsive, and a fingerprint scanner nestles in the upper-left corner. The integrated speakers have a surprising amount of oomph, with good maximum volume and audio clarity, which is ideal for video conferencing.

WELL CONNECTED

Connectivity is decent for an all-rounder laptop, with three USB-A ports, one USB-C (though, sadly, it isn't Thunderbolt-enabled), gigabit ethernet, and HDMI output as well as a Kensington lock slot. The Vero also has Wi-Fi 6 for high-speed wireless internet, which is a nice bonus. There's no SD card slot, however, so photographers might want to look elsewhere.

Where the physical design starts to fall down is the display. It's a run-of-the-mill 1080p IPS panel with a matte finish; no touchscreen here. The maximum brightness is lackluster, making it difficult to use outside or in brightly lit rooms, and color reproduction isn't particularly impressive either. The keyboard is also a weak point, with a little too much spring for our liking and uneven backlighting.

Now sustainability is great, but we're a PC hardware magazine, so sooner or later we had to turn our eyes to the Vero's performance. On paper, its specs are good: there's a four-core, eight-thread Intel Core i7-1195G7 CPU with Iris Xe integrated graphics, backed up by 16GB of DDR4 memory and a 512GB M.2 SSD. The i7 processor performs well in single-core and multi-core workloads, and Iris Xe still impresses us; it's a significant step up from Intel UHD Graphics, and while it won't beat any modern discrete GPU, the Vero is well-equipped for some light gaming at lower settings. Thermal performance is excellent, with only minor heat and noise generated at load.

The Vero is marketed as a multipurpose laptop and lives up to that ideal. The SSD speed was slower than we'd hoped but fast enough that it shouldn't cause problems, provided you aren't routinely transferring huge files. Battery life was also decent, with Acer adding VeroSense, a dedicated power management app that includes an Eco+ mode in addition to the usual Eco, Balanced, and Performance battery profiles.

We were impressed with the Aspire Vero, both in terms of its performance and its eco-minded design ethos. It's not perfect, but we'd like to consider this a blueprint rather than the final image of a sustainable laptop. Hopefully, other manufacturers will follow suit. Props to Acer for taking the first necessary steps.

–CHRISTIAN GUYTON

VERDICT
8

Acer Aspire Vero

+ GREEN THUMB Sustainably designed and manufactured; decent all-round performance; solid speakers.

− OIL SPILL Poor display; keyboard isn't great; a bit heavy for our liking.

$799, acer.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	561	911 (62%)
CrystalDisk QD32 Sequential Read (MB/s)	3,100	2,280 (-26%)
CrystalDisk QD32 Sequential Write (MB/s)	557	316 (-43%)
3DMark: Fire Strike (Index)	1,062	3,598 (239%)
Rise of the Tomb Raider (fps)	5	16 (220%)
PCMark 8 (index)	2,543	4,512 (77%)
Battery Life: Movie Playback (mins)	840	745 (-11%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our notebook zero-point is the HP Spectre X360, with an Intel Core i7-8565U, Integrated Intel UHD Graphics 620, and 8GB of DDR4-2400. Rise of the Tomb Raider is tested at 1080p at the highest graphical profile.

SPECIFICATIONS

CPU	Intel Core i7-1195G7
Graphics	Intel Iris Xe Graphics
RAM	16GB DDR4 @ 3200MHz
Screen	15.6-inch 1080p IPS LCD screen
Storage	512GB M.2 NVMe SSD
Ports	1x 3.5mm Combo Audio Jack, 1x HDMI 2.0, 2x USB 3.2 Gen 1 Type-A, 1x USB 2.0 Type-A, 1x USB 3.2 Gen 1 Type-C, 1x RJ45
Connectivity	Wi-Fi 6, Bluetooth 5.0
Weight	3.97lbs
Size	14.3 x 9.4 x 0.7-inches

The Acer Aspire Vero is an admirable attempt to make a more sustainable laptop.

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Ausdom AW651 HDR 2K Webcam

Conferencing communication companion?

QHD 2K HDR
FHD 1080P/60fps
AUSDOM

IN AN AGE where webcams have become a necessity, it can be a bit of a mission to actually find the right one. Whether you're using a webcam to catch up with family and friends, or you rely on video conferencing in your professional life, you need to choose one that can deliver reliable and clear images and sound.

Typically, many people would turn to a brand such as Logitech, which has been in the webcam game since what feels like the dawn of the internet age. However, one alternative is a relative newcomer called Ausdom. Founded in 2014, it specializes in audio and conferencing peripherals and is becoming more prominent on the webcam front. So should you look past the old trusty favorites and instead turn to one of the new kids on the block?

Unlike a lot of webcams, which have been getting larger and bulkier to the point of not being portable anymore, the Ausdom AW651 is a small and lightweight device. But with webcams often being permanent additions to your setup, this Ausdom cam is the best of both worlds. If you need to take it around with you and use it on a laptop to improve your camera quality, it's compact enough to do so, but its grippy, rubberized mount can also secure it safely to a monitor in a more permanent position.

Despite its diminutive nature, the webcam doesn't feel cheap. In fact, it looks pretty sleek, even sitting on top of a small laptop screen. Our only quibble with the design is that the specs are on the front of the cam. Having the Ausdom logo on the mount section is fine, but it would look a lot better without it telling you the facts and figures every time you glance at it.

Stronger design choices include a privacy slider on the top of the camera, which is always good for peace of mind that you aren't being watched. On the back of the webcam, there's a button to switch the framerate between 30fps and 60fps in 1080p or 720p modes. It's an unusual feature, but handy if you haven't got the software in front of you and want to adjust on the fly.

APP HAZARD

The software is where this Ausdom camera, as an overall package, is somewhat lacking. Of course, you can use the default Windows Camera app or other third-party software but, unlike many other webcams on the market, there's no dedicated Ausdom application.

Ausdom's instructions promote the AMCAP capture software, however, that's for Windows XP, Vista, 7, and 8 users, so not that useful for those of us on current operating systems. We tried it out though and, unsurprisingly, it's rather dated. Thankfully, you can change most of the important settings inside the default Windows Camera app, though.

So, minor issues aside, how does this camera perform? Considering the small lens size, the quality is impressive, especially using the highest 1440p resolution. You don't get the smoothness of the 60fps achieved at 1080p, but we would edge towards the 1440p option on this cam. In a dimly-lit room, the autofocus and auto white balancing do a good job of keeping the colors accurate and the image light and bright.

The dual built-in noise-canceling microphones also have good pickup and can block out background noise pretty well too. Although the Ausdom doesn't offer the widest field of view at 75 degrees, it's more than enough to get you in the frame for a conference call. If you're using this as a streaming cam, you'd probably want a wider shot to get more of your background in the video but, then again, this camera isn't aimed at that market.

For its intended mainstream audience, it's a pretty valiant effort from Ausdom. Having a small and light construction makes it portable, it takes up little space with its low-profile styling, and the mount is grippy with plenty of angle adjustment. You also get a mini-tripod included in the bag, which secures on with a typical tripod screw to the bottom of the camera mount. Also included in the mix is a rather handy cleaning cloth.

However, the main selling point is its sub-$100 price tag and 2K capabilities. It captures a detailed and clear image with good microphone pickup, and despite the poor software availability, it's a great camera for the price. **–SAM LEWIS**

VERDICT
8

Ausdom AW651 HDR 2K Webcam

+ EYES OPEN Compact, sleek design; crisp video quality; good value; clear microphone.

– EYES CLOSED Poor software availability; non-detachable USB.

$90, www.ausdom.com

SPECIFICATIONS

Video resolution	1440p @ 30fps 1080p @ 60/30fps 720p @ 60/30fps
Field of view	75°
Focus type	Auto
Connectivity	Fixed USB 2.0 Type A
Weight	0.18lbs

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MSI Immerse GV60 Streaming Mic

Is this streaming mic a crystal-clear winner?

MSI ALREADY HAS A substantial range of tech and computing peripherals, ranging from monitors and keyboards to mice and even gaming chairs. The company has now extended its arsenal even further by entering the microphone market. The Immerse GV60 streaming mic aims to take on the likes of Elgato, HyperX, and Blue in this area. A standalone mic is an essential part of a streaming setup, but is the GV60 a clear winner for Twitch use?

MSI products are usually aimed at the budget to mid-range market but, from first impressions, the GV60 appears to be more premium than that. Weighing in at 2.42lbs, it's a heavy microphone that feels extremely sturdy on a desk due to its thick rubberized base. The construction is an all-black matte aluminum design with touches of gunmetal gray.

Compared with some of MSI's other products, many of which sport bold, eye-catching designs, the GV60 looks and feels like a premium device with no cheap plastics in sight. In fact, at first glance, it's hard to tell that this is an MSI product, with only the presence of two subtle logos give that away.

Included in the box is a foam pop filter, although the GV60 looks much better without it. There's also a USB-C to USB-A cable measuring 3m in length, which is enough for you to move around the room without having to stop recording. Also included are two screw cover caps if you want to take off the desk stand and use it on a boom arm. This connects through the use of the 5/8-inch boom arm screw hole on the bottom of the mic, however, an arm is sadly not included.

The microphone is convenient to use and being a simple plug-and-play device, you can start using the GV60 in no time at all, without the need for additional software and drivers. In terms of the design, all the controls are on the front. There are three vertical control dials and a mute button that sits below these. One gripe we had is how close these dials are to each other, as it's easy to accidentally knock the other controls and adjust the wrong one.

The top dial gives you the option to switch on-the-fly between four recording modes. There's a stereo mode for recording both left and right channels, useful for capturing vocals and streaming. The omnidirectional mode is good for recording multiple voices at once in a conference call, perhaps if you're in a meeting gathered round a table.

There's also a cardioid mode that directly records in front of the mic to cut out unwanted background noise, which is ideal for podcasts. The final mode is bi-directional recording, capturing audio from the front and back of the mic for instrument recordings or one-on-one interviews. Having all of these features on one dial is much more efficient than opening up an application.

Below the dial is the headphone volume and below the mic is a 3.5mm jack. This provides you with zero-latency playback, great for monitoring your recordings. Lastly, there's also a dial for the microphone volume—all of these dials are well built and turn smoothly.

NAILED IT

For a first attempt at a standalone microphone, MSI has hit the nail on the head. With a studio-grade 24-bit/96kHz sample rate, this microphone picks up audio with great clarity. Of course, if you're live streaming, the software will likely condense to a sample rate of 48kHz, but having this quality at hand is great for other recording purposes.

When using the microphone close up on calls, the pop filter works effectively to smooth the audio and cut out background noise. Regardless of what we've been recording, the GV60 is capable of tackling it all with high-quality reliable audio.

As a streaming mic, it compares well to other similarly-priced alternatives such as Elgato's Wave:3 microphone, one of our current go-to mics. However, it is a diverse microphone with enough adjustability to use in many different situations. We found the ability to switch between the different modes came in handy when using this in a gaming party chat with pals and also it in our more formal weekly Google Meet calls.

With a great premium feel, pinpoint directional recording, and crystal clear audio quality, this is a great all-rounder and a positive step for MSI in the audio recording market. **–SAM LEWIS**

VERDICT
9

MSI Immerse GV60 Streaming Mic

+ TUNING IN Premium feel; multiple recording modes; high quality recording rate; plug and play.

− TUNING OUT Awkward control dials; slightly bulky.

$130, www.msi.com

SPECIFICATIONS

Sample rate	96kHz
Bit rate	24-bit
Frequency response	20Hz-20kHz
Microphone sensitivity	36dB (±3)
Recording modes	Stereo, omnidirectional, cardioid and bidirectional
Connection	USB-C to USB-A
Weight	2.42lbs

©MSI

SteelSeries Arctis 7+ Wireless Headset

Another impressive Arctis headset?

WHILE THERE'S no doubt SteelSeries has nailed its gaming headset designs, the ever-expanding nature of its range can be confusing. Take this 7+ model—it's an upgrade on the standard 7, but below the more premium 9 series, which also has a Pro version. Confused? Thankfully, we're here to help.

On the design front, it's no surprise this is a comfortable pair of headphones. SteelSeries' ski-goggle headband is one of the best on the market, suspending the headset from a steel band and creating an even pressure across your head thanks to the elasticated headband. This makes the headphones feel lightweight whilst still being durable. The rest of the construction is strong, with soft-touch black plastic feeling pleasant to hold, with no sharp edges in sight. The earcups are cozy around the ears, with plenty of cushioning to spread any potential pressure evenly. The result is that the 7+ provides cloud-like comfort, and maintains SteelSeries' reputation for the best gaming headsets on the market.

But what about functionality? On the right earcup, there's a power button that also functions as a multimedia button for picking up calls, playing music, pausing, and skipping tracks. It also has an LED indicator that shows the power left in the battery, running from green down to red. Above the power button, you also get a wheel for balancing between game or voice chat which is perfect for adjusting the audio mix on the fly.

On the left can, there's a mic mute button, a smooth volume wheel, a port for a four-pole 3.5mm audio cable, and a headphone share jack to allow friends to join in the music—a rarity on most gaming headsets. Finally, there's a retractable microphone, which boasts great clarity and pick-up so you're always clear when talking to your squad in party chat. It's worth noting this updated 7+ model now also boasts USB-C charging, which means you should always have a charging cable around you can use.

Another great feature of the 7+ is the impressive 30-hour battery life, though if you've forgotten to charge it overnight, 15 minutes of quick charging is enough to get you a few hours of use. That's plenty of time to go grab some snacks before an evening gaming session.

The Arctis 7+ comes with an odd-looking USB-C wireless dongle, but it has a wide range of compatibility. You can use this headset on PC, Mac, PlayStation 4/5, Nintendo Switch, Android (if it has USB-C connectivity), and any 3.5mm device. Although these headphones have analog, USB, and wireless connectivity, they don't have Bluetooth, unlike its pricier sibling, the Arctis 9 Wireless.

Sound quality from the 7+ is what you'd expect from SteelSeries. Out of the box, the naturally flowing soundscape focuses on the high-end, providing you with plenty of clarity and detail which sounds great in most games. Using the SteelSeries GG engine and its Sonar tool, you can tweak the sound to suit your taste. Increasing the bass gave the headphones a fuller and richer sound, which ticks all the boxes, sonically.

If you're looking for a reliable, comfortable headset that provides versatile compatibility then you won't be disappointed with the Arctis 7+. It's an updated version of a solid device and features some modern touches that its predecessor lacked. SteelSeries has nailed the formula and has produced another well-rounded pair of headphones with a detailed soundstage.

If Bluetooth is a must, then you should try the Arctis 9 Wireless. If not, the Arctis 7+ does everything you need. **–SAM LEWIS**

VERDICT
8

SteelSeries Arctis 7+ Wireless Headset

+ MASTER CHEF Pillow-like comfort; clear microphone; well rounded sound; diverse compaptibility.

− TOO MANY COOKS No Bluetooth connectivity; similarly priced to Arctis 9 wireless; odd-shaped USB-C dongle.

$170, www.steelseries.com

SPECIFICATIONS

Driver Type	40mm Neodymium driver
Frequency Response	20Hz-20,000Hz
Impedance	32ohms
Connectivity	Analog, 2.4 GHz lossless, USB-C
Compatibility	PC, Mac, Playstation 4, PS5, Nintendo Switch, Android
Battery life	30+ hours
Design Style	Closed-back

Vissles V84 Pro

A challenger approaches

THE MECHANICAL keyboard market is nothing if not saturated at this point. Gamers and typists alike are spoilt for choice, with a vast range of sizes, styles, and switches available. RGB lighting has become ubiquitous. Unique proprietary switches are becoming incredibly common, a marked shift from the days when the only widely available options were red/blue/brown Cherry and Gateron switches.

Vissles is a newcomer to the market, founded in 2018 and launching its flagship mechanical keyboard, the V84, in 2021. In addition to its odd name, Vissles also has a weird slogan plastered all over its website and on the V84's box: 'Poppin Your Life With Ease'. The 'About Us' page isn't forthcoming with an explanation.

Perhaps it refers to how the original V84 (and the model we're reviewing here, the updated V84 Pro) features easily hot-swappable keycaps and switches, which can be 'popped' out with included tools and replaced with caps or switches of your choice. You can order the V84 Pro with pre-installed Cherry MX switches, however, our review unit comes with Vissles' VS II mechanical switches, which surprised us greatly in terms of how good they feel to use.

The VS II switches are linear-standard, with a remarkably smooth actuation and low operating force. They have 4mm of total travel, registering input at 2mm, which makes them feel comfortable for typing. The light actuation is also great for gaming, with every keypress feeling immediately responsive. These are also some of the quietest linear switches we've come across, which is a bonus for anyone located in the immediate vicinity.

The overall design is simple, but don't take that as a criticism; we like the V84's stripped-back look. It uses a 75 percent keyboard layout, which is rare even in tenkeyless (TKL) keyboards (60 percent and 80 percent are more common), so naturally offers some pre-loaded macros to make up for the missing keys. Like many compact keyboards, the V84 Pro is wireless via Bluetooth 5.1, although you can also use a USB-C cable.

GRIPPY TEXTURE

The exterior is plastic, but it doesn't feel cheap. The V84 Pro is weighty, preventing it from shifting around during use, with a matte black base and white PBT keycaps. These keycaps have a pleasing, slightly grippy texture under your fingertips, and the overall build quality is excellent. There's no flimsiness and no flex in the case when speed typing. Vissles includes a padded leather wrist-rest in the box, which feels well-made, along with some alternative keycaps for Mac users (with a keyboard shortcut to swap modes).

Vissles has also seen fit to include LED backlighting. This offers 19 preset effects spanning the usual range of rainbow colors, and can be tweaked along with custom key bindings and macros in the Vissles desktop app. This is functional but rather ugly and underwhelming, like a lot of proprietary keyboard software.

The RGB lighting is fine, but since the PBT keycaps are opaque, the backlighting is limited to illuminating around the edges of the keys. It's also not particularly bright, meaning that it's barely noticeable in a brightly lit environment (although it does look great in a dark room). It also causes some minor issues with practical use; for example, turning on caps lock or scroll lock lights up the corresponding key in white, which is near-impossible to see around the white keycaps.

The V84 Pro is rated for up to 180 hours of use with the lighting turned off, and we can confirm it didn't need charging once in the time we spent with it. With a price of $109, it sits somewhere in the middle of the mechanical keyboard market, but we'd consider it good value for money. It's rare that a brand we're unfamiliar with surprises us so pleasantly; if you're on the hunt for a new TKL keyboard, we'd strongly recommend the V84 Pro.

–CHRISTIAN GUYTON

VERDICT
9

Vissles V84 Pro

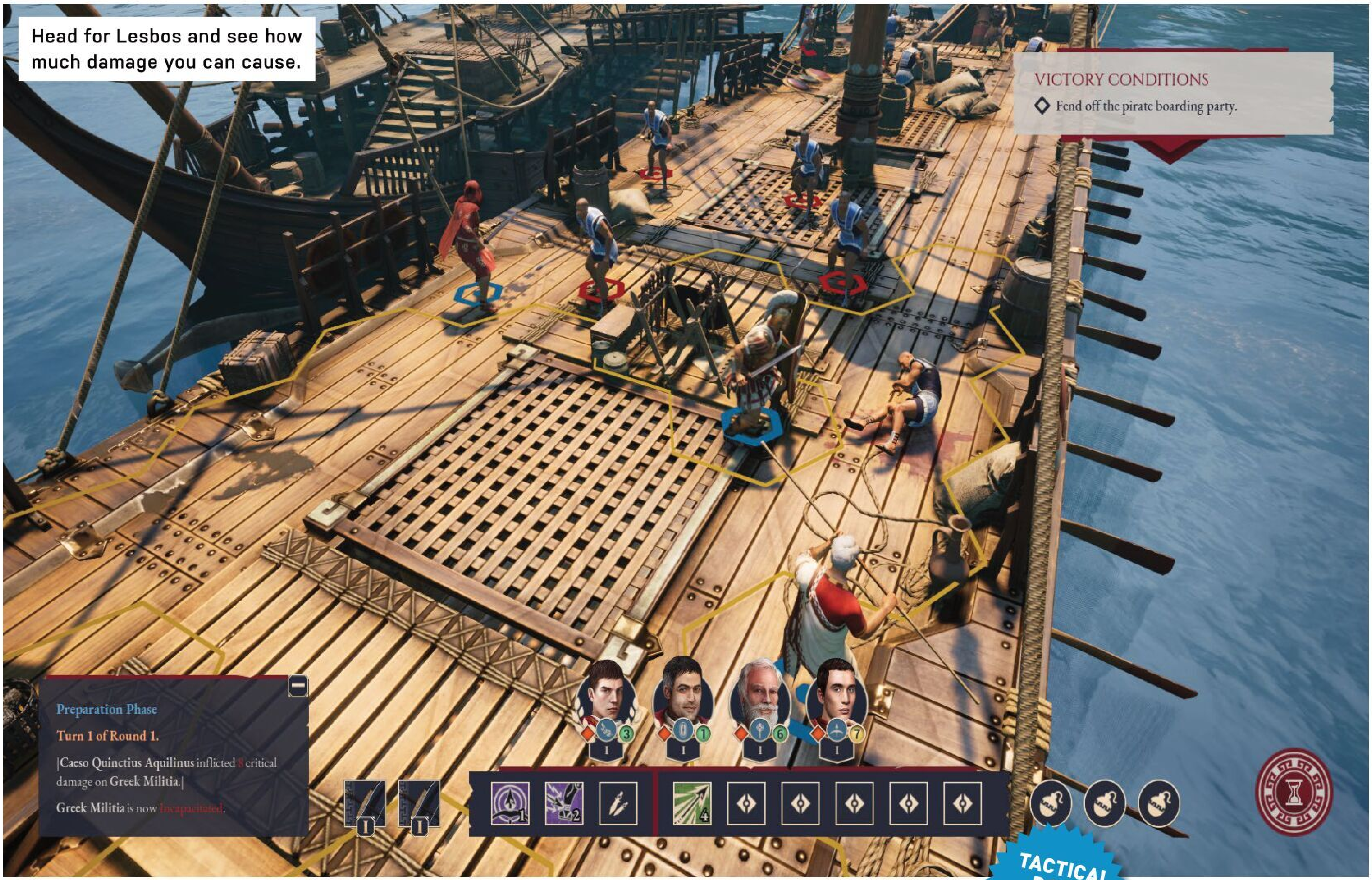
⊞ **POPPIN** Great battery life; VS II switches are good; clean design; comfortable wrist rest.

⊟ **POOPIN** Software is unimpressive; opaque keycaps cause issues with lighting functions.

$109, vissles.com

SPECIFICATIONS

Switch Type	VS II Mechanical Switch
Switch Durability	60 million presses
Media Keys	Integrated w/ function keys
Connection	USB-C/Bluetooth 5.1
Battery Life	180 hours
Wrist-rest	Separate leather padded
Dimensions	4.96 x 12.44 x 1.54 inches



Head for Lesbos and see how much damage you can cause.

VICTORY CONDITIONS

◇ Fend off the pirate boarding party.

Preparation Phase

Turn 1 of Round 1.

|Caeso Quinctius Aquilinus inflicted 8 critical damage on Greek Militia.|

Greek Militia is now Incapacitated.

TACTICAL ROLE-PLAYING GAME

Expeditions: Rome

Clearly not built in a day

AS A SETTING, ancient Rome has much to recommend it. There's the strong military culture, the mad gods, the orgies, the wine, gladiators, philosophers in togas (or was that Greece?), and a general lack of medical care.

Expeditions: Rome takes that military culture and spins it into a turn-based RPG in which you, as the scion of a famous leader, take command of armies and do an awful lot of talking. It starts off small, as you lead a disparate group you've met on a boat to Lesbos to kill guards and blow up ships with Greek fire, but scales into the command of whole legions, besieged cities, and doing more and more of the aforementioned conversing.

Standing between you and all this is the character creator, which allows you to create a custom-ish character—options are limited and we never really felt like we were in control—and then choose a 2D portrait that appears in dialog that looks nothing like the 3D model. Having chosen a portrait with lustrous curly hair and the face of actor Eddie Redmayne, we were then unable to match it with the 3D character choices, all of whom looked more like Russell Crowe. It's possible to create female characters too, with the game referencing the expected roles of women in Roman society even as you make your way up the military ladder.

Developer Logic Artists has produced historical RPGs before and has worked on a canceled (or placed on hold for 'an unspecified period of time') project with Larian Studios, the minds behind *Divinity: Original Sin* and *Baldur's Gate 3*. As you'd expect from such experienced hands, the actual RPG mechanics—the leveling up and allocation of skills—is smoothly handled. You get one skill point per level gained and choose a new ability from skill trees that are all available at the start, based on the class you chose.

It works nicely, although it's possible to miss the actual moment of leveling up in the heat of combat and have to be prompted by an 'unused skill point' popup after swords have been sheathed. At least the prompt exists. There's some amusing text in the popups that open over things like game difficulty choices right at the beginning of the game, pointing to a studio that's enjoying what it does and expects you to as well.

Given its setting, it's perhaps ironic to criticize the game for feeling old-fashioned, with its curious overhead camera that doesn't allow you to zoom out far enough or tilt over to see particularly far ahead, and things like the first two military camps you visit being completely identical, that's certainly the impression. Conversations also feel basic—they are essentially dialogs between your 2D character portrait and other characters, with responses directly selectable, and new ones opened up depending on your character traits.

If you don't feel like talking, there's always a fight to be had. Combat is based around movement and actions, your single action point allowing you to get a hit

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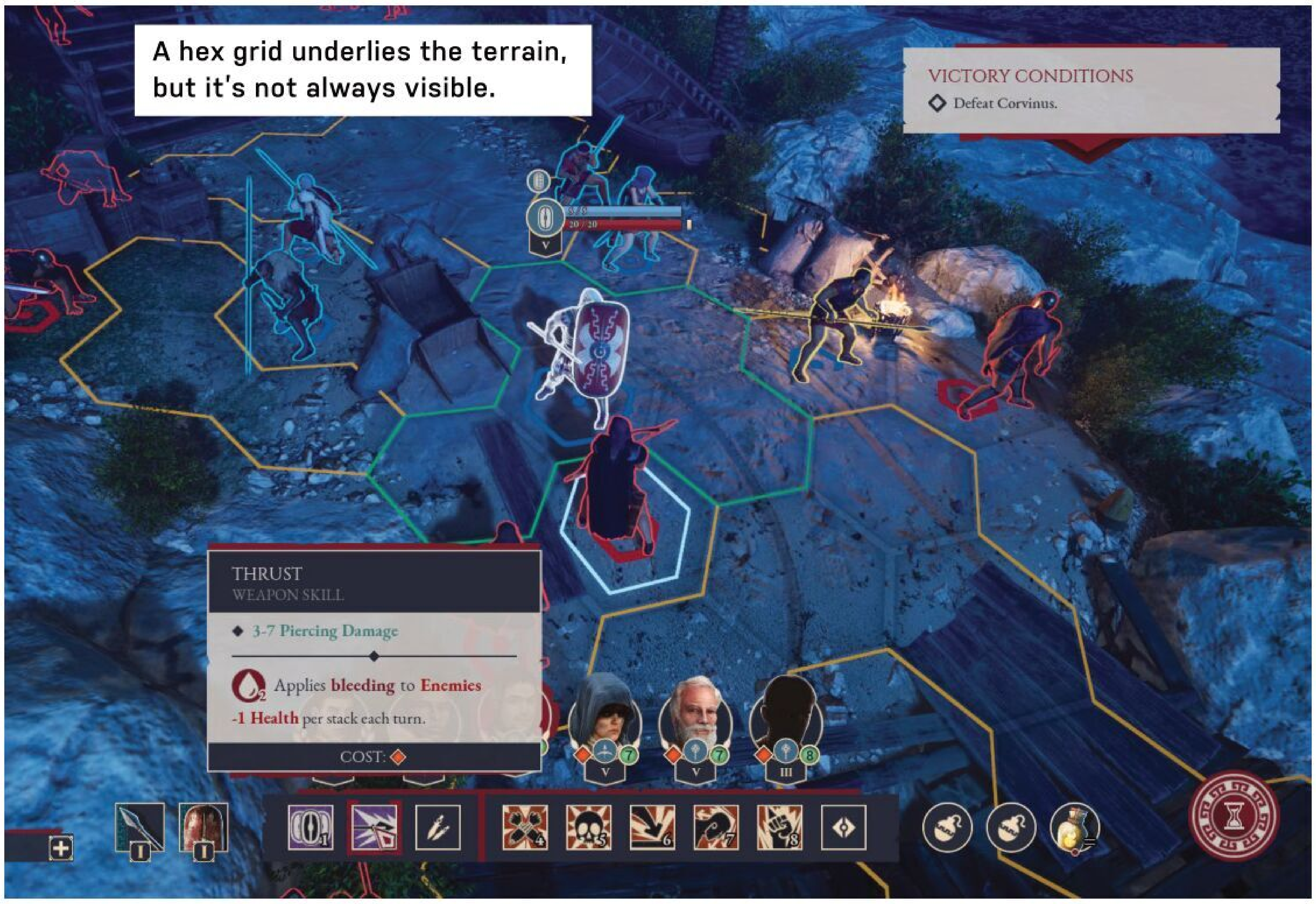
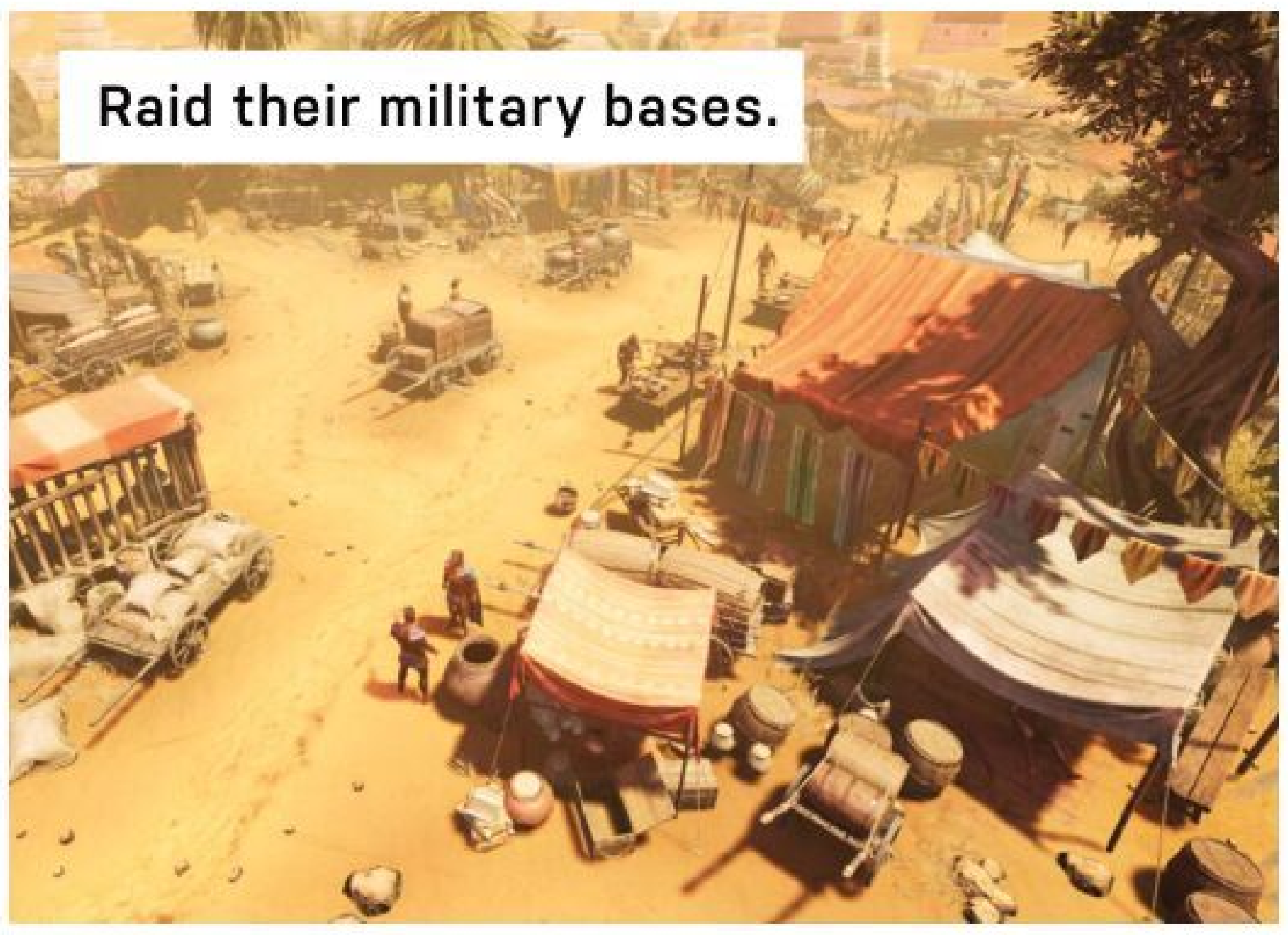
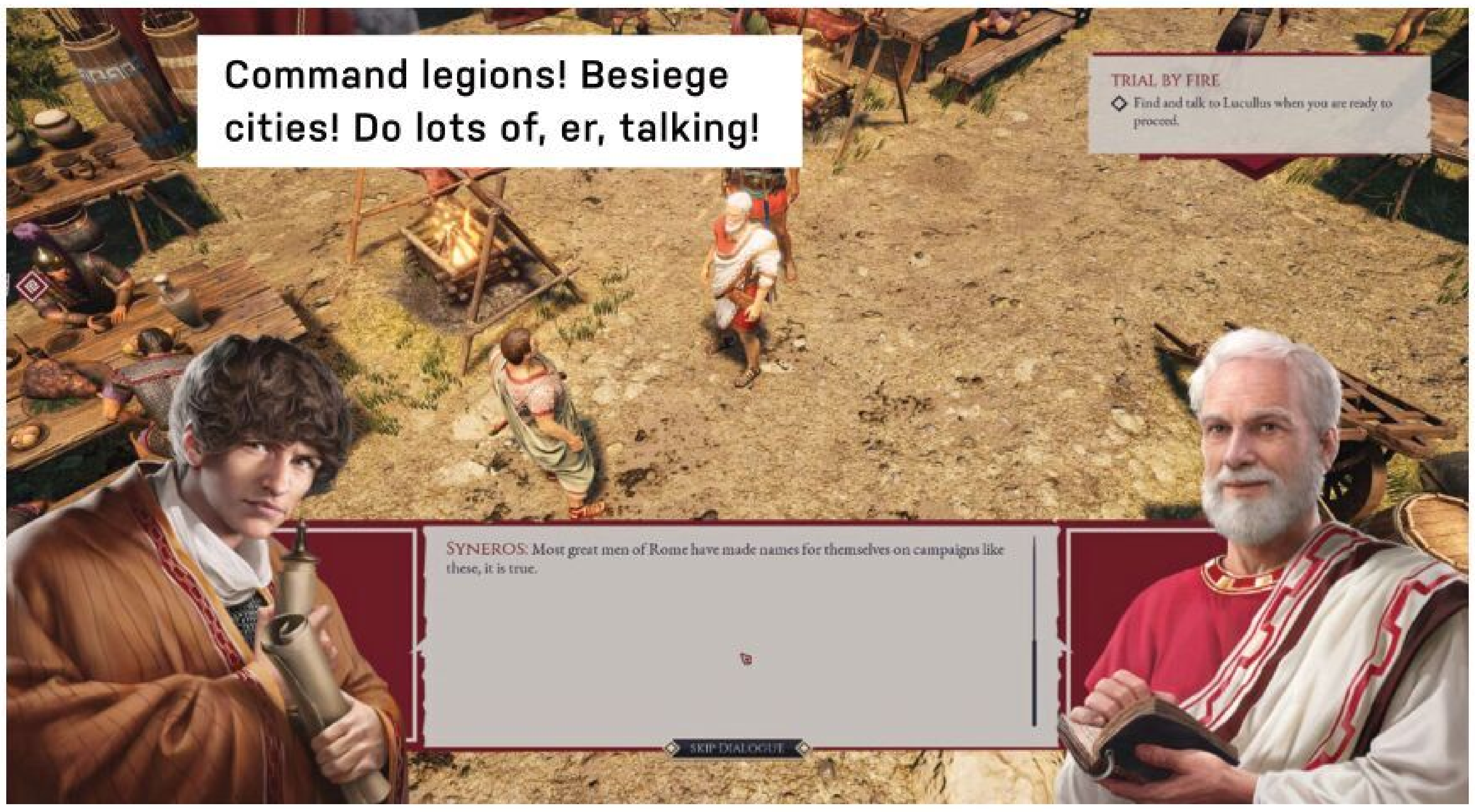
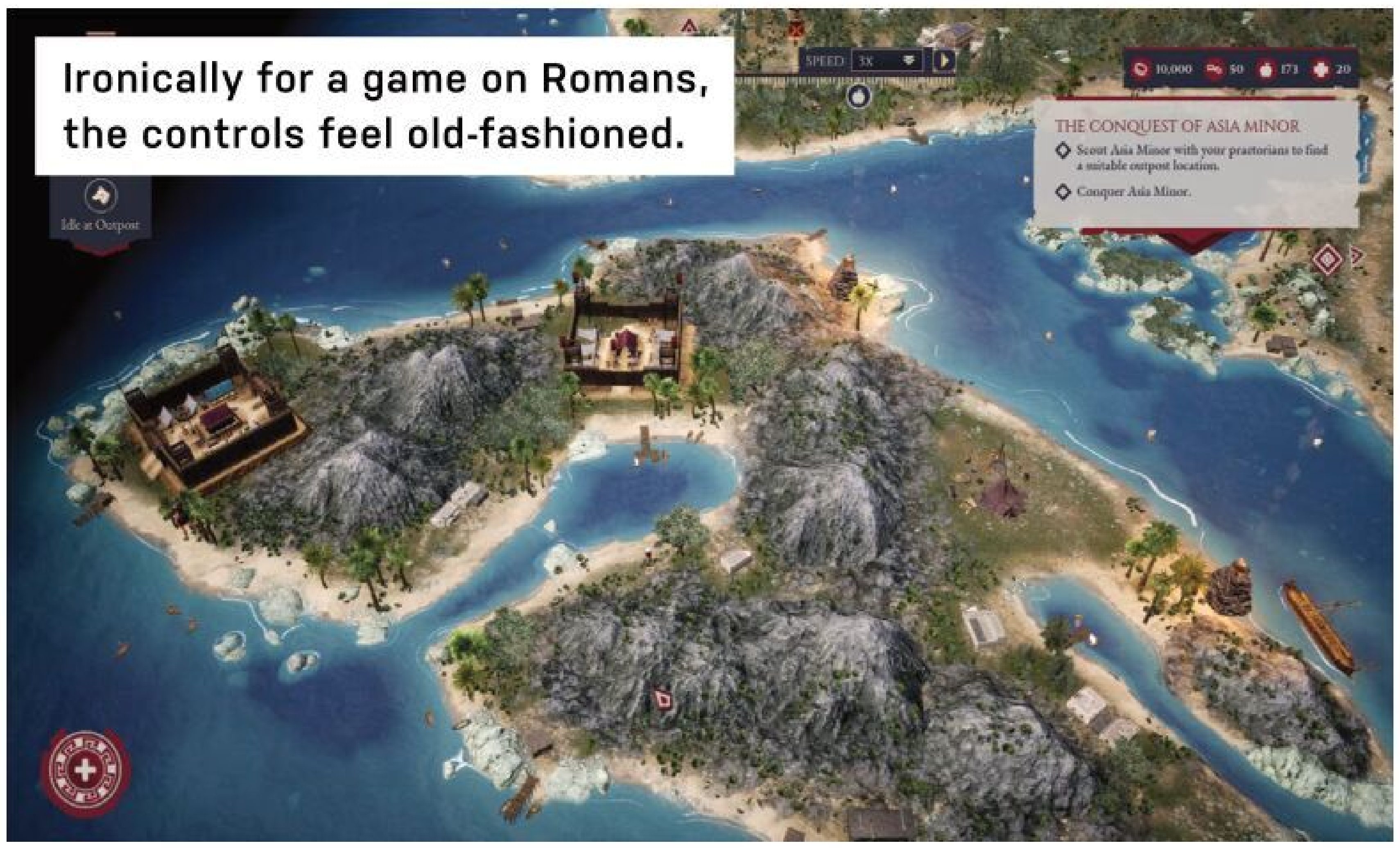

A hex grid underlies the terrain, but it's not always visible.
VICTORY CONDITIONS
Defeat Corvinus.
THRUST
WEAPON SKILL
3-7 Piercing Damage
Applies bleeding to Enemies
-1 Health per stack each turn.
COST:

Set fire to their ships.
VICTORY CONDITIONS


Raid their military bases.


Command legions! Besiege cities! Do lots of, er, talking!
TRIAL BY FIRE
Find and talk to Lucullus when you are ready to proceed.
SYNEROS: Most great men of Rome have made names for themselves on campaigns like these, it is true.
SKIP DIALOGUE


Ironically for a game on Romans, the controls feel old-fashioned.
THE CONQUEST OF ASIA MINOR
Scout Asia Minor with your praetorians to find a suitable outpost location.
Conquer Asia Minor.

in after moving into position, and possibly letting you run away again afterward. The opening of the game sees a tutorial against pirates who board your boat and quickly reveal one of your party, who has a skill that refunds his action point if he makes a kill, to be an absolute powerhouse despite being armed with a stick. Sending him wheeling across the deck pounding already weakened pirates into the planks gives you a sense of what's possible with the combat system, which includes cover as well as attacks of opportunity and a form of overwatch, despite this opening being the worst part of the game.

It soon gets better, however, with a raid on a Greek dock to burn enemy ships. The build-up to this sees you attack a warehouse where Greek fire (think pots of napalm) is being stored. You get the choice of making your approach directly or taking out the camp of enemy reinforcements first. The problem with this is that iron-age combat is rarely silent, and the warehouse will be alerted to your presence by their soldiers' screams. We opted to take out the camp first, which has the benefit of lowering the number of guards at the main target.

Armed with the firebombs, we attacked the dock, and immediately got another choice: sneak up on one of the ships and burn it immediately, or walk into the middle and start the attack there. We burned the ship, but managed to miss the bright red target hex (there's a grid underlying all of this, but it's not often visible) and set the wrong part of the ship on fire. We're no experts, but a fire on any part of a wooden ship should be cause for concern, however, it didn't seem to bother the crew. We got it right the next time and left the dock in ruins.

From there, *Expeditions: Rome* expands into a huge RPG, your battles scaling from these dirty melees to those in which you command legions at a distance. Real-life figures such as Cicero and Cleopatra appear, and the game likes to throw in snippets of conversational Latin. How accurate they are, we couldn't say, but they add immensely to the atmosphere of a bustling Roman settlement.

Looking old-fashioned and front-loaded with its worst bits, *Expeditions: Rome* does itself few favors when you first get going. Persevere, though, and anyone looking for a novel RPG set in an impressively authentic historical setting will find a lot to like about it. **–IAN EVENDEN**

VERDICT 7

Expeditions: Rome

+ OPTIMUM Immersive world full of choices and dialog; spiced up by fights, large and small.

– MALUM Could do with a graphical makeover; camera restrictive; maybe too much talking?

RECOMMENDED SPECS
CPU, Ryzen 5 1600X / i5-9500F. RAM, 16GB. GPU, Vega 56 / GTX 1070.

$45, logicartists.com, Rated T for Teen

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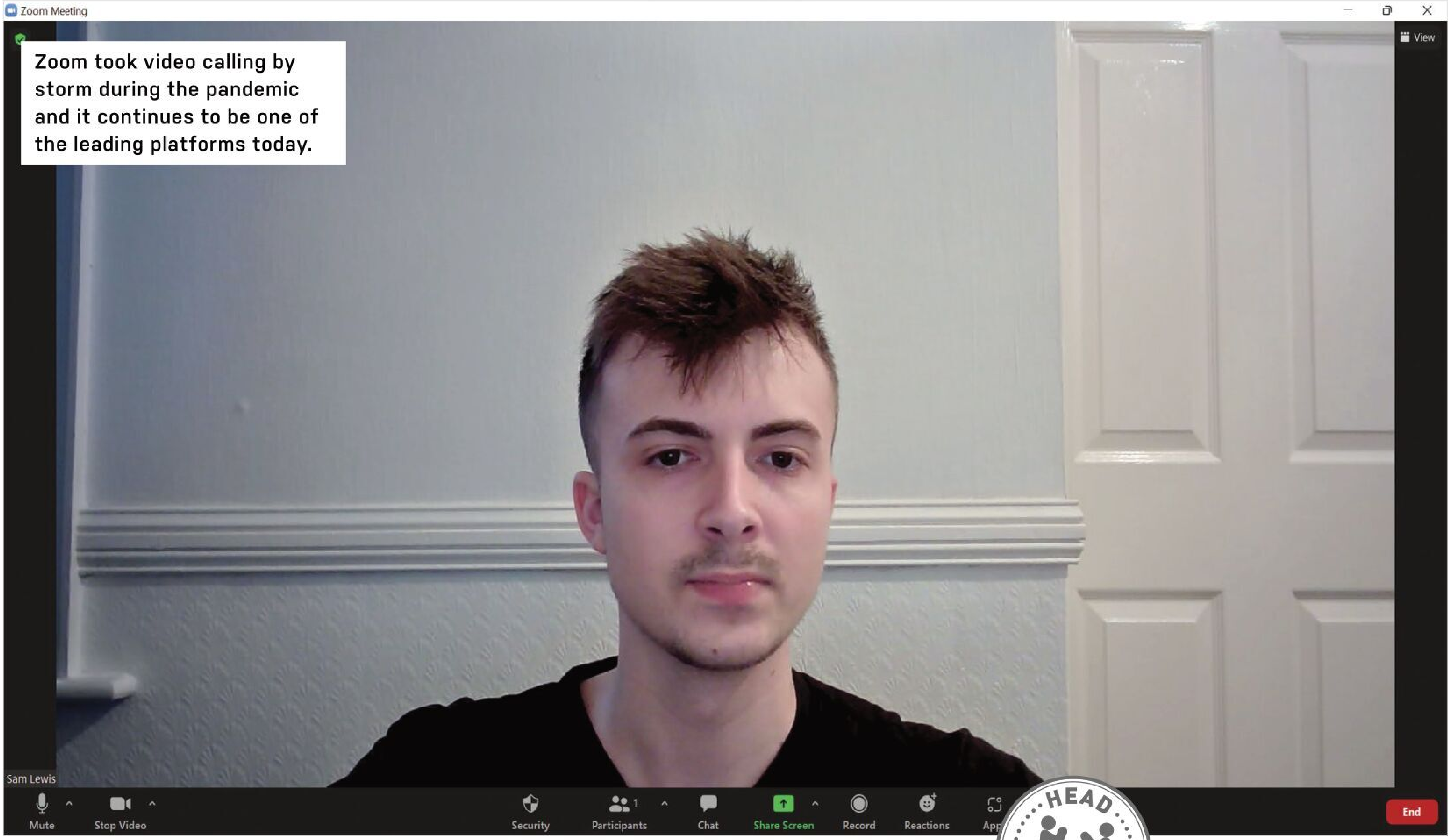

Zoom took video calling by storm during the pandemic and it continues to be one of the leading platforms today.

Zoom vs. Google Meet

Two video conferencing services, which is better?

OVER THE PAST DECADE, the proliferation of camera-enabled devices and free video calling platforms has made video conferencing accessible to all. Even your grandparents have probably been getting in on the act. Of course, the pandemic really kicked things up a gear but, even as life slowly returns to normal, we're still heavily reliant on the technology. Whether it's business meetings, remote working, or family gatherings, video conferences kept our lives going during a tricky couple of years. And now we've gotten used to it, that doesn't look like it's going to change.

Video conferencing is nothing new, and the concept has been around for a while. At the 1964 World's Fair in New York, Bell Labs introduced its new invention, the Picturephone. This device was a 5-inch black and white screen paired with a camera. For $16, you got three minutes in a public booth in New York, Washington DC, or Chicago and the ability to connect with another Picturephone user. Of course, at nearly $145 in today's money, the technology was far too costly to catch on.

It wasn't until AT&T's Videophone 2500 in 1992 that video calling became feasible. The color video was transmitted over a regular phone line and didn't cost the user any more than a typical phone call. However, it was the arrival of the internet that was the real driver behind the video calling boom.

Skype was one of the first applications, becoming so popular during the past decade that it is now a byword for video calling. As the technology snowballed, many similar applications were created that we still use today—the likes of FaceTime, which brought portable video calling to the mainstream, plus Google Hangouts, Microsoft Teams, and many more. Two of the most popular video conferencing services are Google Meet and Zoom. These two have been most prevalent in the last few years and both have personal and commercial uses. But the question is, which should you choose?

While our first impressions of software are usually formed on the basis of the user interface, there are two major differences between Google Meet and Zoom. The former is browser-based, while Zoom is application-based. There are pros and cons to each when it comes to design. Typically, a dedicated application makes the experience feel more polished. Zoom has more scope for the user to tweak the size of the window, for example, while its application homepage is well laid out, making it easy to start or join a video call.

However, Google Meet has a clean aesthetic across the board. Keeping things clear and easy to navigate, while avoiding the user interface looking boring is a strong point. This also applies to the design of the calls—Zoom's interface looks cluttered in comparison, as everything is labeled extensively. This makes it easier for newcomers or first-time callers, but once you know your way around the layout, it looks messier than Google's offering. In a Meet call, Google uses a clever range of icons for a cleaner look. The icons are self-explanatory, but you can hover your mouse over them to find out what they do. We would give Google the edge in terms of user-friendliness and overall design.

One of the main reasons for the popularity of these two video conferencing services is the number of features they both offer. Zoom leaped to prominence during the first lockdowns at the start

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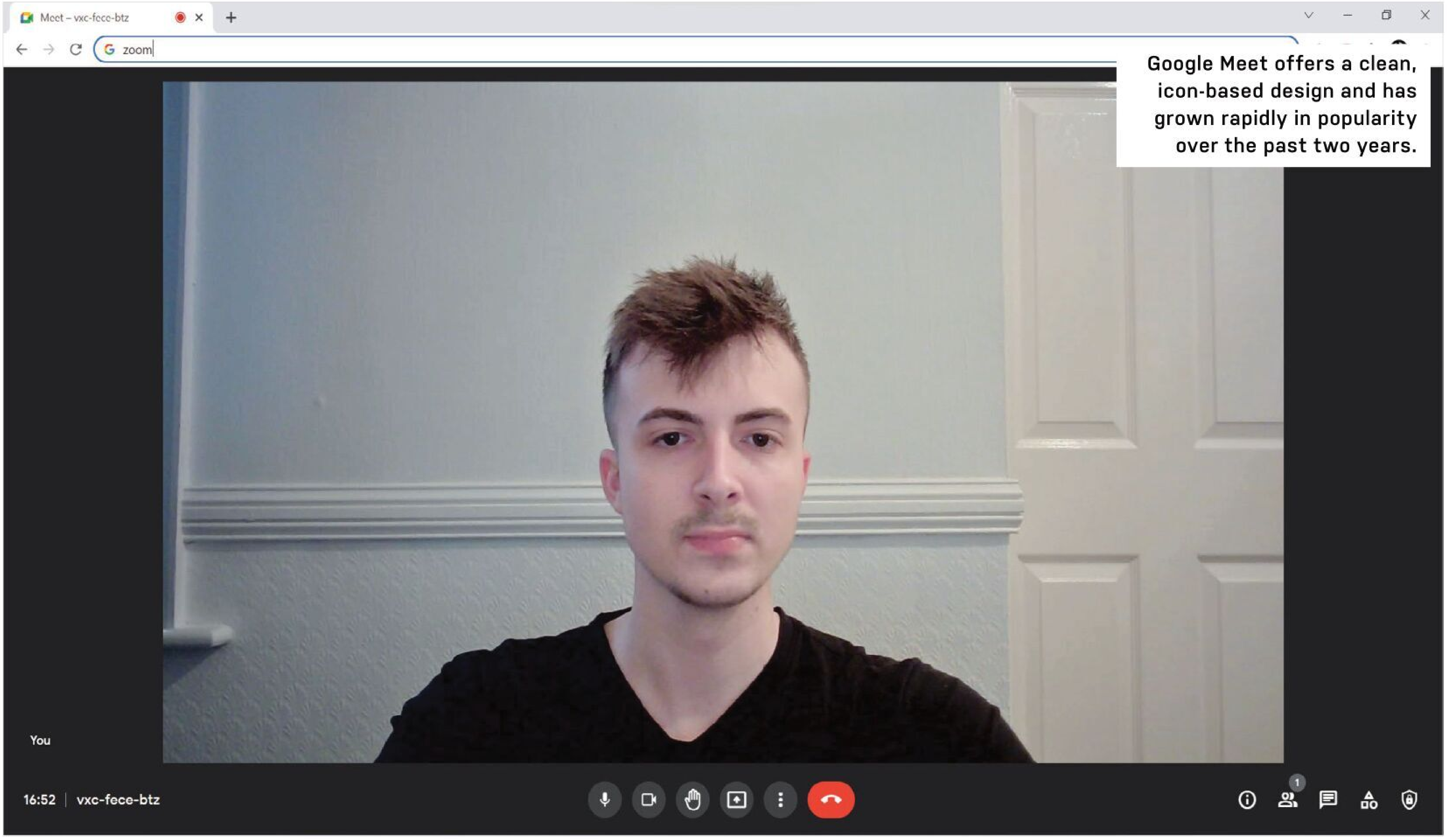


Google Meet offers a clean, icon-based design and has grown rapidly in popularity over the past two years.

of 2020, when video calls became an essential means of communication. As a result, many businesses opted for Zoom as their go-to service as they could use it for one-to-one chats as well as company-wide meetings. Google Meet didn't quite have the same functions but, two years later, it's fair to say that it has stepped up its game in terms of its functionality.

In this comparison, we are focusing on the free options of Zoom and Meet, though both also have paid variants with additional functions. Both free versions offer unlimited meetings, Full HD video, screen sharing, layout options, chat, background filters, and a maximum capacity for up to 100 participants. For the majority, this will be more than enough. Zoom has more to offer with its free option, as you also get features such as whiteboard, remote mouse and keyboard control, waiting rooms, telephone dial-in, and polls—quite a step up from Google's offering.

Though Zoom delivers a richer experience, one major positive for Google Meet is that it offers live closed captions. These allow you to receive subtitles for the call, improving the user experience and overall communication. Another key point is that free Zoom calls are capped at 40 minutes, whereas Google's are an hour long. This could be the difference between being annoyingly cut off or not, or might encourage you to make meetings shorter, though that could be a plus for some.

© GOOGLE

Meet also comes with Google's suite of applications, a huge ecosystem of browser-based tools that are easy to use and access, no matter what device you are on. If you're already a Google user, Meet will keep all your tools in one place.

One downside of Zoom is that you have to download the application. Within the app, there are also third-party apps you can use. The Zoom app store offers a range of group games and the option to add even more functions, but this has caused security concerns. Security and privacy are a vital part of video conferencing, the last thing you want is hackers entering your private business calls. Zoom has had to quickly ramp up its security measures for commercial and domestic video calling.

Meanwhile, Google's security has set the precedent for other online companies. Both services offer encrypted calls, two-factor authentication, access codes, and also the option to remove unwanted participants from the meeting. So, it's a tie between platforms on security, Zoom wins on functionality, while Google is easier to use and has a crisper design.

Both Zoom and Google Meet are capable video conferencing tools that offer a reliable experience. If functionality is your thing, then go down the path of Zoom, however, for a more seamless experience, we'd choose Google Meet. Google's applications follow a clean and uncluttered style that is up there with the likes of Apple. Meet isn't far behind Zoom when it comes to functions, plus it has more than enough features for the average video call meeting, but the extra call time you get over Zoom and live captions make it a better service. So, Google Meet is our choice between the two and takes the crown as the king of the free video conferencing platforms. The browser availability, clean UI, and ease of use place it above Zoom, making it a more fluent and faster experience. **–SAM LEWIS**

VERDICT 8

Zoom

MAGNIFY Rich in features; encrypted calls; free dial-in capability; third-party games and apps.

REDUCE Slightly cluttered design; requires you to download application.

Zoom Basic $free, Zoom Pro $15/month, Zoom Business $20/month, Zoom Enterprise $20/month. www.zoom.com

VERDICT 9

Google Meet

HELLO Very clean UI; user friendly; browser based; free live captioning; encrypted calls.

GOODBYE No remote keyboard and mouse functionality, no integrated group games.

Google Meet $free, Google Workspace Individual $8/month, Google Workspace Enterprise (contact company for pricing). meet.google.com

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> More Letters, Less iFixit!
> Get Good at GIMP
> Sub-par $2K laptops

iDontFixIt

I'm a long-time subscriber to *Maximum PC*, and I just wanted to say congratulations to Guy on being named the new Editor-in-Chief. Now, may I make a couple of suggestions? In general, I really enjoy the magazine. Probably some of the most informative items are 'Doctor' and 'Letters', so it would be terrific if those could be expanded.

You probably have a page limit and so to do that, some things would have to go. I'd lose the iFixit and the PC Centerfold instead—iFixit is online and anyone can access it, while Centerfold could be one of the reviews in the back. Just some ideas for consideration.

–N. Weinshenker

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS: First of all, thanks for the warm welcome! Perhaps a career in magazine editing beckons because it's like you've read my mind! The eagle-eyed among you will have noticed the lack of iFixit this issue. However, we will still return to it as and when there's something interesting, such as the one I can't wait for in the next issue! And no matter what issue it is, *Maximum PC* will always be packed with tutorials on how to get the most out of your PC, whatever you do on it.

I think you make an interesting point on Doctor and Letters. I've edited many publications, but nowhere have I seen the quantity or quality of letters we get here on *Maximum PC*, so I'll bear it in mind. In the meantime, you can get involved in a more synchronous form of discussion with readers and the team on our official Discord channel at: http://bit.ly/MPCDiscord.

GIMP Guidance

I've been a regular reader of *Maximum PC* for the past three or so years and always look forward to each month's issue. I enjoy the mix of hardware, software and IT articles that the magazine offers. Those retro Machine of the Month pieces sure bring back some memories.

The last few issues have showcased Sam Lewis's skill in graphic design using various Adobe suite applications. However, I was wondering if there was any chance of similar tutorials using open source tools such as GIMP. Clearly, GIMP is not in the same class as Photoshop but not everyone has an Adobe CC subscription—as a hobbyist, it's hard to justify the expense. It would be great to see what can be accomplished with open source or free tools in the hands of someone skilled like Sam. **–D. Heintzman**

STAFF WRITER, SAM LEWIS, RESPONDS: Thanks for the feedback and while I do enjoy a bit of graphics work, our art editor Fraser may have something to say about my skills! On your question though, GIMP is definitely something I'll consider. I've not used it intensively before but we have featured it in the magazine, so it would be good to use it in a tutorial.

In the meantime, bear in mind that a lot of the same principles transfer between the two programs, albeit with different buttons and shortcuts. If you're coming to GIMP from Photoshop, there are some great tools online that allow you to reprogram the former to work like the latter, including shortcuts and appearance. Like I say, there's plenty for me to cover, so thanks for the tip!

Bytesize History

Your February 2022 article, *The Best of Maximum PC*, stirred not only the memories of your publication but its predecessors as well. I purchased an Apple II Plus for $3,000 in the late 1970s with 48K ram, a floppy disk drive, and an integer basic card. I also loaded up on all the magazines at the Byte Shop Computer Store, including *Kilobaud Microcomputing*, *Dr. Dobbs Journal*, *Apple Cider*, *Creative Computing*, and *Byte Magazine*, and each month I would return to the store and purchase the next issues. I eventually subscribed to *Byte Magazine*, and when that ceased publication, my subscription was transferred to *Boot*, which then became *Maximum PC*.

I've maintained my subscription since then, and have enjoyed not only the articles and reviews but

↘ submit your questions to: editor@maximumpc.com also the humor. I remember laughing so hard at your review of the Logitech Z80 speakers, when you hooked up 12 speakers and cranked them up so loud that none of the ensuing complaints could actually be heard!

Over the years, your reviews have guided my purchases, from those Logitech speakers (I'm still rocking them today) to the Matrox 400 graphics card with a TV tuner, to various CPUs and motherboards along the way.

I'm not a gamer, but I do have a drawer full of broken video cards thanks to their tiny fans freezing up, so I was really happy to learn about the Ryzen G series CPUs with integrated graphics. I now have three such systems, including the most recent AMD Ryzen 7 5700G. In addition, I have a new passion for the Raspberry Pi since learning about it in *Maximum PC*, for which I was able to program my own threader interpreter language, but that's another story.

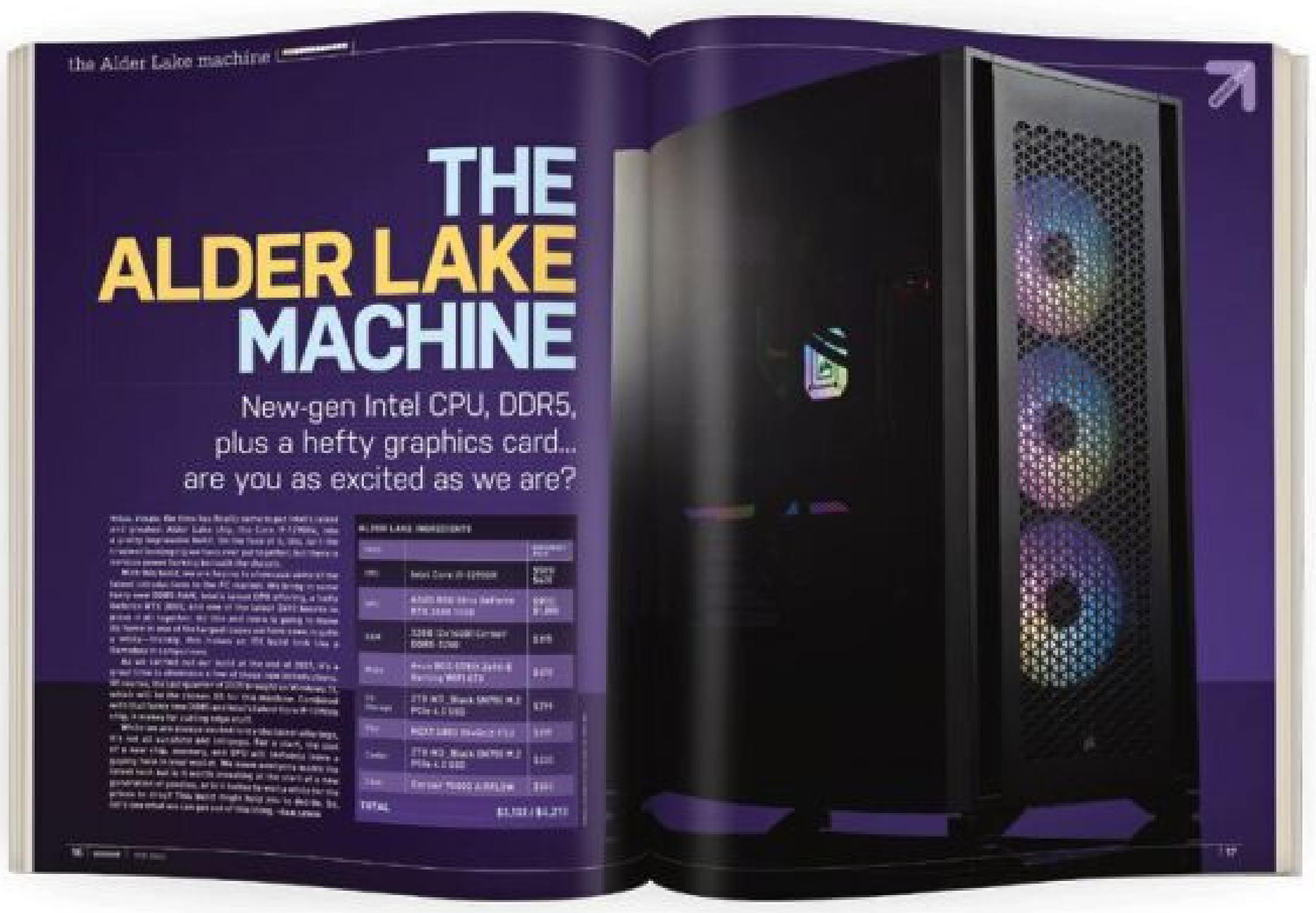
I've really enjoyed the most recent in-depth articles by Ian, Chris, Nick, and Jeremy, along with the memories from reviews of past systems I've owned over the decades. I'm looking forward to the new Editor and the magazine's continued success for the next 20 years, if I make that long. Keep up the great work! **–G. Holcomb**

Kick-Ass Reader

I am an owner of a copy of the very first edition of *Maximum PC*, and I am glad I held on to it. I have always been a fan of the magazine, and I love the Kick-Ass reviews. **–R. Rodekurt**

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS: Thanks so much for these letters—I'm sure they will warm the hearts of the many people who have worked on *Maximum PC* over the past 25 years.

[CORRECTIONS]



THE ALDER LAKE MACHINE

New-gen Intel CPU, DDR5, plus a hefty graphics card... are you as excited as we are?

On Page 16 of our February 2022 issue, we erroneously listed an SSD in the cooler section of our ingredients list for the Alder Lake build. The featured cooler should have been the **Corsair iCUE H170i Elite Cappelix AIO**. We apologize to our readers, and to Corsair, for any confusion caused.

We also stated in our February 2022 review of the EPOS Adapt 360 headphones that EPOS fell under the Sennheiser umbrella when, in fact, the two companies operate a co-branding agreement. *Maximum PC* regrets the error and apologizes to EPOS for any confusion caused.

As mentioned, our February 2022 issue looked back on around 300 issues of the magazine, which started life as *Boot* in 1996 and morphed into *Maximum PC* two years later. This feature is one of the reasons I love magazines because going back to them is like exploring a time capsule of PC ownership at the time.

Some things seem twee (like the jump to the first 1GHz processor), while others demonstrate how the more things change, the more they stay the same (like our constant disappointment with new versions of Windows). I also love looking over the old covers and marveling at the crazy photoshoots.

Your letter is also a reminder that while plenty of our readers do care about games and graphics, not everyone wants (or needs) to spend loads on a GPU these days.

Thankfully, integrated graphics have gotten better on desktops, as Sam found out in his $600 build last issue, while laptop chips from AMD and Intel this year also look to be making a generational leap forward. We'll have plenty of coverage on those this year, so we're glad to have you with us.

Ghost in the Machine

I'm a business guy who loves PCs, is a great fan of *Maximum PC*, and has poured lots of dough into what I thought were good business laptops (Lenovo, mostly). However, I don't seem to get great battery life or performance from my $2,000+ laptops.

I'm also a photographer and videographer and those things have not really challenged my machine. Meanwhile, it takes almost two minutes to boot, loading programs should be a snap but it's not, and the whole experience is disappointing for the sum of money I've invested.

I'm starting to think that a laptop with gaming specs might be the way forward. What do you think? I'm fed up with watching little circles and clocks on my screen while waiting for pretty ordinary programs to load. I'd appreciate your help. **–L. Babin**

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS: As a gamer myself, I would usually recommend a gaming laptop to anyone, but not in your case. You haven't mentioned that you enjoy playing games in your letter and, while a GPU would give your Adobe Premiere Pro video encoding a nice boost, you said you're barely pushing your machine as it is.

As a photographer and businessperson, I'd imagine you use your machine on the road, and gaming laptops are notoriously big and heavy. They aren't known for their battery life—many, such as my Lenovo Legion 5 Pro, allow you to reduce the screen refresh rate, turn off the dedicated graphics, and even use a portable USB-C charger, but they're not going to offer you 'all-day' battery that will allow you to move between meetings without a charger.

My first port of call on your current laptop would be to go into Windows Settings and select Power & Battery. In there, you can see your battery usage for the last week and see what's using the most power—I was shocked to see Google Chrome taking 71 percent of my power use over a week. Then go to the Lenovo Vantage app that should be installed on your machine, and check the Battery section to see its overall health, as it could be time for a replacement. Thankfully, these are fairly cheap to buy from Lenovo and easy to install yourself.

If you still just want a new laptop, I'd recommend a Dell XPS 13 or a Microsoft Surface Laptop. Both are stylish, powerful, and boast long battery life. ⏻

THE BUILDS

THIS MONTH'S STREET PRICES...

BUDGET

THIS MONTH'S BUDGET improvements are focused on the Intel build, as we rebuilt the AMD one last month and were unable to find any reasonable upgrades or cost savings. There's a lot happening with Intel at the moment, including an extraordinarily priced CPU that means we can upgrade a few of the other components, as well as a new high-value GPU entry in the market. The first tweak is the Intel Core i5-12400F, the same processor featured in our $1300 build this month, minus the onboard graphics processor. You will need a discrete graphics card for this build, so if you're unable to get one, or you're holding out for whatever reason, be sure to look at the standard i5-12400 at $210. The i5-12400F, though, is only $25 more than the Intel Core i3-10400 we used to feature in this build but offers double-digit performance gains in both single and multi-core operations. It offers incredible bang for your buck, which is why we wanted to feature a build around it this issue.

Another component of the cover feature has made it into our budget build, the newly-released Nvidia 3050. We won't pretend these are going to be easy to get hold of, but they are selling for a lot less online than the 3060 card we featured last month. We still wouldn't spend any more than $400 on these cards, but it's your decision. As we found in our review this month, the 3050 is a capable little 1080p card with plenty of memory and all the usual Nvidia features we love, such as ray tracing and H265 encoding.

We also upgraded the motherboard to an LGA1700 model and chose the cheapest ATX model we could find with the ASRock B660 Pro RS. You could get that down to $100 with the Asus PRIME H610M-E D4, but it's a Micro ATX so has fewer PCI and RAM slots. Finally, taking advantage of the ASRock motherboard's PCIe Gen4 port, we pinched the XPG GAMMIX S50 Lite SSD from the AMD build and put it into the Intel one. This will offer speed benefits over the previous 500GB Samsung 980 NVME but costs only $10 more.

AMD INGREDIENTS

PART		PRICE	STREET PRICE
Case	Corsair 4000D Airflow	$95	
PSU	550W Corsair CV550 80+ Bronze **NEW**	$45	
Mobo	MSI MPG B550 Gaming Plus AM4	$160	
CPU	AMD Ryzen 5 3600	$230	
GPU	MSI Radeon RX 6700 XT 12 GB MECH 2X	$480	$900
RAM	16GB (2x 8GB) Crucial Ballistix CL16 @ 3600MHz	$115	
SSD	512GB XPG GAMMIX S50 Lite PCIe 4.0 M.2 SSD	$70	
HDD	4TB WD Blue 5400 HDD	$65	
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32	

Approximate Price: $1,292 or $1,712

INTEL INGREDIENTS

PART		PRICE	STREET PRICE
Case	Corsair 4000D Airflow	$95	
PSU	550W Corsair CV550 80+ Bronze	$45	
Mobo	ASRock B660 Pro RS **NEW**	$140	
CPU	Intel Core i5-12400F **NEW**	$180	
GPU	Gigabyte RTX 3050 Gaming OC **NEW**	$380	$560
RAM	16GB (2x 8GB) Crucial Ballistix CL16 @ 3600MHz	$85	
SSD	512GB XPG GAMMIX S50 Lite PCIe 4.0 M.2 SSD **NEW**	$70	
HDD	4TB WD Blue 5400 HDD	$60	
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32	

Approximate Price: $1,087 or $1,267

MID-RANGE

NOT TOO MUCH CHANGE on the mid-range front this issue, but on the plus side, there were some cost savings to be made. The dependable, but 18-month-old, AMD Ryzen 5 5600X dropped by $30 this month, perhaps reflecting Intel's competition in this price bracket. That's not to knock this six-core, 12-thread processor, though, which is still more than capable of complementing the Radeon RX 6800 XT, a new entry last month. Speaking of graphics cards, the Nvidia RTX 3070 GPU we picked last month had a significant street price reduction for this issue, down around 10 percent to $968. No such sales for the RX 6800 XT in the AMD build, however, which dropped only slightly to $1350. As capable as the card is, that's a hefty premium.

Last month's power supply option, the Corsair RM750x, went up in price slightly this month to $100. We like this fully modular power supply and there are often retailer offers around that bring it down by $20. If not, then the 750W EVGA SuperNOVA GA is slightly cheaper and just as capable, thanks to its 80+ Gold Rating and fully modular design. It's only available in black, however, so stick with the Corsair if your build isn't going to be of the stealth variety.

The other tweak we made this month was to the AMD's motherboard. The Asus AM4 TUF Gaming X570 Plus WiFi went up about $5 this month to hit a $190 price point—still good value for all that it offers, but more expensive than ASRock's gaming focused-board. The ASRock doesn't offer Wi-Fi, so if that's important, factor in a USB dongle or powerline adaptor, but otherwise it offers all the important features you'd want from a mid-range board, including a PCI Express 4.0 M.2 slot for the super-fast Samsung 980 Pro drive.

The final point to note is that last month's Intel cooler, the Enermax Liqmax III 240 RGB, had gone up by $25 over last month. So we elected to swap in the Cooler Master MASTERLIQUID ML240L RGB V2, another 240mm cooler that boasts RGB lighting, but one with a slightly more tolerable price point.

AMD INGREDIENTS

PART		PRICE	STREET PRICE
Case	Lian Li PC-011-Dynamic	$170	
PSU	750W EVGA SuperNOVA GA 750 W **NEW**	$95	
Mobo	ASRock X570 Phantom Gaming 4 **NEW**	$140	
CPU	AMD Ryzen 5 5600X	$230	
Cooler	280mm Cooler Master Masterliquid ML280 Mirror ARGB	$75	
GPU	MSI Gaming Radeon RX 6800 XT 16 GB	$899	$1,350
RAM	16GB (2x 8GB) Acer Predator Apollo CL16 @ 3600MHz	$109	
SSD	500GB Samsung 980 Pro NVME M.2 PCIe 4.0 SSD	$100	
HDD	4TB WD Blue 5400 HDD	$60	
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32	

Approximate Price: $1,910 or $2,361

INTEL INGREDIENTS

PART		PRICE	STREET PRICE
Case	Lian Li PC-011-Dynamic	$170	
PSU	750W EVGA SuperNOVA GA 750 W **NEW**	$95	
Mobo	ASUS Prime Z690-P LGA 1700	$210	
CPU	Intel Core i5-12600K	$280	
Cooler	Cooler Master MASTERLIQUID ML240L RGB V2 **NEW**	$68	
GPU	MSI Ventus GeForce RTX 3070 8 GB	$570	$968
RAM	16GB (2x 8GB) Corsair Vengeance RGB Pro SL RGB CL16 @ 3600MHz	$109	
SSD	500GB Corsair Force MP600 M.2 PCIe 4.0	$95	
HDD	4TB WD Blue 5400 HDD	$60	
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32	

Approximate Price: $1,689 or $2,087

TURBO

IT'S GOOD NEWS this time around for our AMD build, a $100 sale on the powerful AMD Ryzen 9 5900X brings our CPU down to $450. Unfortunately, the Ryzen 5950X hasn't been struck with the same luck, otherwise, we'd swap chips here. This processor is, of course, no slouch and is still one of the best offerings from AMD right now.

To help costs and get some extra speed improvements, we opted for the Sabrent Rocket 4 Plus 1TB SSD over the previous Samsung 980 Pro of the same capacity. Saving $10 doesn't sound like much but it's a win-win scenario here, with increased read/write speeds and more bucks to spend elsewhere. The rest of the build doesn't change, prices remain roughly the same with a few fluctuations on the cooler and motherboard. The ASRock Radeon RX 6900 XT is still available and prices haven't altered, so that is one step in the right direction. We are also keeping the MSI MAG CoreLiquid 360R ARGB in both builds, although it rose by $10. This is a neat-looking cooler that will do the trick in both high-end rigs.

On the Intel side, we see a sale on our i9-12900K CPU, not quite as good on this side of the fence but any decrease in price is welcome. We have a few more changes on this build though, kicking things off with a price drop that has made us extremely happy. For a small increase of $16, we swap out our Gigabyte RTX 3080 for the Ti variant. This model brings us 12GB of GDDR6X, 2GB more than the standard 3080 offering from Gigabyte, and was a no-brainer.

A compatibility issue meant that we had to swap out the newly added MSI MAG CoreLiquid 360R ARGB cooler for the Corsair iCUE H150i RGB PRO XT. With the same 360mm radiator size, it should perform similarly, although it's not as quiet as the MSI offering. And that was it for the changes on the Intel Turbo build, albeit they were some pretty exciting ones. The only other differences were similar to those on the AMD machine, with a few price alterations but nothing to worry about. The majority of them were positive, the only negative being a $10 rise in our Gigabyte Aorus Gen4 SSD. Not a bad compromise for an almost free upgrade to an RTX 3080 Ti.

AMD INGREDIENTS

PART		PRICE	STREET PRICE
Case	Phanteks Enthoo Pro 2 Tempered Glass	$220	
PSU	750W Be Quiet! Pure Power 11 FM 80+ Gold	$115	
Mobo	Gigabyte X570 Aorus Elite	$180	
CPU	AMD Ryzen 9 5900X	$450	
Cooler	MSI MAG CoreLiquid 360R ARGB	$140	
GPU	ASRock Radeon RX 6900 XT Phantom Gaming D 16GB	$999	$1,499
RAM	32GB (2x 16GB) G.Skill Ripjaws V 32GB @ 4000MHz	$140	
SSD	Sabrent Rocket 4 Plus M.2 PCIe 4.0 **NEW**	$160	
HDD	6TB WD Blue 5400 HDD	$120	
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32	

Approximate Price: $2,556 or $3,056

INTEL INGREDIENTS

PART		PRICE	STREET PRICE
Case	Phanteks Enthoo Pro 2 Tempered Glass	$220	
PSU	750W Be Quiet! Pure Power 11 FM 80+ Gold	$115	
Mobo	MSI PRO Z690-A WiFi LGA1700	$240	
CPU	Intel Core i9-12900K	$600	
Cooler	Corsair iCUE H150i RGB PRO XT **NEW**	$130	
GPU	Gigabyte Gaming OC GeForce RTX 3080 Ti 12GB Gaming OC **NEW**	$1,199	$1,580
RAM	32GB (2x 16GB) Kingston FURY Beast DDR5 @ 5200MHz	$350	
SSD	1TB Gigabyte Aorus Gen4 M.2 PCIe 4.0 SSD	$140	
HDD	6TB WD Blue 5400 HDD	$120	
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32	

Approximate Price: $3,146 or $3,527

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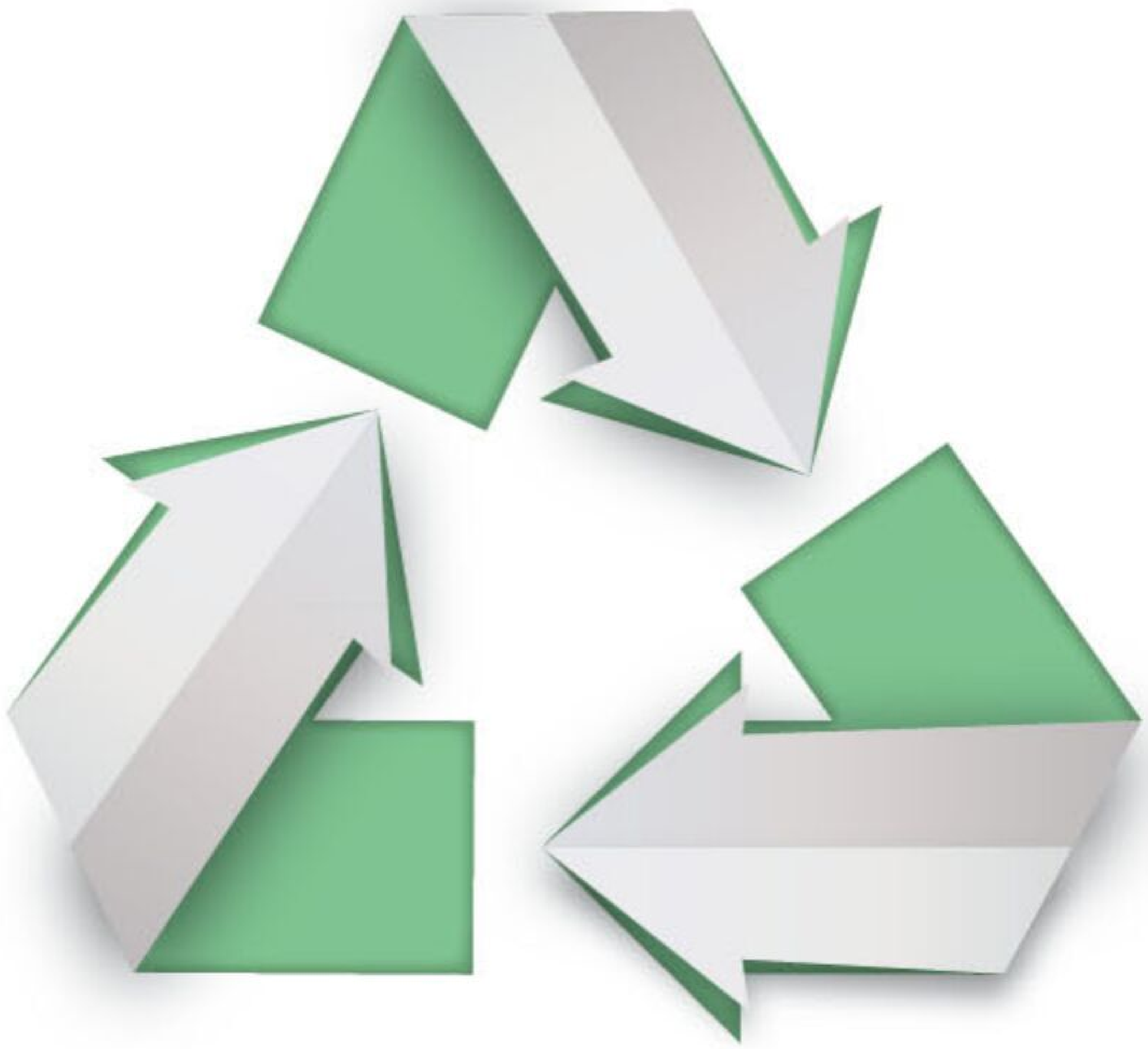

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